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POPE LEO XIII.

FROM THE PAINTING FROM LIFE BY CHARTRAN.

PORTRAIT OF HIS HOLINESS THE POPE.

WE give on our first page an engraving of the magnificent portrait of his Holiness Pope Leo XIII. painted from life by the distinguished artist Theobald Chartran, which attracted great attention in the salon of the Champs Elysees, Paris. This is said to be the first and only portrait painted from life of the Sovereign Pontiff, and represents in the most artistic manner the benign features and general expression of goodness which so habitually enlightens the face of the Holy Father. Our picture is from *La Ilustracion Española*.

PHOTOGRAPHS IN NATURAL COLORS.*

Produced by the Improved Process of L. Lumiere, after Professor Lippmann's Interference Method.

By LEON WARNERKE.

THANKS to the great kindness of M. L. Lumiere, of Lyons, we are able to examine to-night the latest results obtained by him. A few explanatory remarks are necessary to make the method of their production generally intelligible. About two years ago Professor Lippmann, of the Sorbonne, in Paris, succeeded in producing photographically a colored image of the solar spectrum, based on the well known principles of interference. He used for that purpose a plate coated with an albumen, collodion or gelatine sensitive film. This sensitive film was, during exposure, brought into contact with metallic mercury, the image of the spectrum being projected on the film through its glass support. The light, after penetrating through the thickness of the film, was reflected back from the surface of the mercury, the direct light waves encountering the waves of reflected light, producing the phenomenon of interference in the thickness of the film. The waves of light propagating in opposite directions cause the vibrations at certain intervals to be neutralized, while at others they are intensified. If such a plate could be developed, fixed and dissected, we should find it to consist of strata of the black deposit of silver, produced by the developer in the parts corresponding with the maximum of light, succeeded by transparent strata corresponding to the minimum of light where the developer had no action. The distance between the strata is equal to half the wave length, which is 600 ten-thousandths of a millimeter for red light, 583 for orange, 551 for yellow, 475 for blue and 423 for violet. In a film $\frac{1}{10}$ mm. thickness there will be about 200 such strata. It is evident that on examining such a plate by reflected light we shall observe the colors, because it is formed of a series of films of the thickness requisite to produce color sensations. Subsequent experiments proved that by using a gelatine film sensitized with a chromium salt, a similar result is obtained, the action of interference producing strata of soluble and insoluble gelatine.

The exposure of the plates produced by Lippmann was very long, and, owing to the variation of sensitiveness of different rays of the spectrum, necessitated the masking of the portions exposed to the more actinic rays, while the others are exposed. L. Lumiere succeeded in producing colored images in one operation, and in last May, in a paper read before the Paris Academie de Science, gave full particulars of the process as follows:

ABSTRACT.

To prepare the emulsion the following solutions are made:

A—Distilled water	400	parts
Gelatine	20	"
B—Distilled water	25	"
Potassium bromide	2·3	"
C—Distilled water	25	"
Silver nitrate	3	"

One-half of A is added to B and the other half to C. These two solutions are mixed by adding the silver to the bromide. A suitable sensitizer is added, such as cyanine, methyl violet, erythrosine, etc., and after filtration plates are coated on a tourniquet at a temperature of 40° C.

When the emulsion is set the plate is immersed in alcohol for a very short time and washed in a continuous stream of water. The film being very thin, the washing is soon effected. This emulsion should not be washed in bulk, lest coarseness of the particles of silver produced by reheating results, and in order to have the films as transparent as possible; for the same reason a great excess of bromide is to be avoided. The plates are dried, and just before use are immersed for two minutes in

Water	200	parts
Silver nitrate	1	part
Acetic acid	1	"

This bath helps to produce brilliancy of the image and to increase the sensitiveness. But the plates cannot then be kept long, because the sensitive surface soon deteriorates. When the plate is dry it is ready for exposure *a la* Lippmann, viz., with a reflecting surface of mercury next to the film.

For the developer the following solutions are made:

I—Water	100 parts		
Pyrogallic acid	1 part	Sol. I	10 parts
II—Water	100 parts	Sol. II	15 "
Potassium bromide	10 "	Sol. III	5 "
III—Ammonia D. 0·960 diluted to 18°.		Water	70 "

The degree of concentration of the ammonia has a great influence on the result, even a slight alteration destroying the brilliancy of the colors. For fixing, the plate after washing is immersed for from 10 to 15 seconds in a 5 per cent. solution of potassium cyanide, washed and dried.

In order to lessen the action of the ultra-violet, violet and blue rays, a parallel-faced bath of Victoria yellow, uranin or primuline is used in the camera.

The pictures lent by M. Lumiere are 6 by 8 cm. in size, and when seen at a certain angle show colors of unsurpassed beauty—beyond anything we are accustomed to see in the way of the reproduction of colors—somewhat metallic in appearance, but very bright and of very decided and definite color.

* From Transactions of Photographic Society of Great Britain, October 11, 1893.

To examine them direct, the best plan is to use the reflected light of a bright sky, or if a lamp must be used, it is preferable to have the light reflected from a white shade or opal globe.

To appreciate all the beauty of these photographs, the image should be lit by a powerful light (preferably electric) and a projection made on a screen by means of a portrait lens (4 in. diameter). The result is then of such beauty as to defy description—it is not like an oil painting or a water color; it is like real nature on a bright summer's day. Seeing these first photographs in natural colors we feel we are in the presence of one of the greatest inventions of the nineteenth century, and we may sincerely congratulate our friends on the other side of the channel upon so splendid an achievement.

PERFUMES AND PERFUMERY.

LADIES who devote some study to the selection of delicate perfumes, and have by temperament and practice become connoisseurs in the detection of subtile and delightful odors, will be gratified to learn that this faculty is a preservative of health. When the cholera prevailed in Paris and London, all the people engaged in the work of preparing perfumes escaped its ravages, and when the Dutch destroyed the spice trees on the island of Ternate, the colony suffered from epidemics and diseases previously unknown. So those accustomed by the culture of their sense of smell to use perfumes not only find in the perfume itself a prophylactic against some forms of disease, but are themselves enabled acutely to detect the presence of noxious and poisonous atmospheres.

The increasing use of perfumery in commerce has enriched many parts of the world, and France, India, Turkey, and Italy to-day enjoy a handsome revenue from the sale of flowers and materials cultivated exclusively for this industry. It is believed by experts, notably Mr. R. S. Cristiani, of Philadelphia, that the United States is entitled to compete with these countries in the production of the articles used in perfumery. There are many sections of our country where flowers could be raised on a large scale, and capital inducements offered to enterprising men to start a new venture of this sort, where success means fortune. From the earliest times perfumes have been popular among the priests and administrators of religious rites, as they have used incense at the worship of their deities. In those ancient days the Egyptians, as in most other things, preceded the rest of the world in the use of perfumes, and from them it passed to Assyria, Greece, Rome, Arabia, and Turkey. The Asiatics, attracted by their luxurious tastes to all sorts of sensuous indulgences, found perfumes a necessary accessory in their daily pleasures. Nineveh and Babylon, according to Herodotus, consumed such enormous amounts of perfumes that, besides the production of their own country, they obtained from Arabia "a thousand talents of frankincense."

Alexander found among the spoils in the camp of Darius quantities of essences and cosmetics; and the Romans and Greeks used perfumes, and the many ointments into which they entered, most lavishly. The Orientals are addicted to musk, whose powerful odor has for them a great attraction. To such an extent is the love of perfumery carried, that there is said to be a mosque the mortar of which is mixed with musk, so that its walls become fragrant when the sun shines upon it, and the air of this temple becomes itself steeped with this penetrating scent.

Perfumes became fashionable in the reigns of the great kings and queens, and Elizabeth, Queen of Hungary, is said to have invented the famous Hungary water, by the use of which she retained her beauty until she was past seventy years of age. Perfumery exists among all races, and ranges from the Australian and Esquimaux, whose taste is vulgar and low, to the highest delicacy of perception in a Beau Brummell.

Mr. Cristiani, in his valuable work on perfumes, from which the above facts are culled, tells us that, though we obtain valuable perfumes from the East, the south of Europe is now the only reliable source of supply—Cannes, Grasse, and Nice being the principal seats of flower culture. Cannes excels in the culture of the rose, cassia, jasmine, and tuberose; Nismes in rosemary and lavender, Nice in violet and mignonette, and Sicily in the citron and orange. British India gives us cinnamon, cloves, patchouly, santal, ylang-ylang, and odoriferous gums and spices. China yields musk, civet, and ambergris. England furnishes lavender and peppermint, for which its moist climate is peculiarly adapted, while we are indebted to Italy for the citric odors, as lemon, bergamot, cedrat, limette, neroli, etc.

It is interesting to note that the odors of plants exist in different parts of them, sometimes in the wood, as in cedar and santal; sometimes in the leaves, as in patchouly and thyme, in the seeds, as in caraway and tonquin, in the bark, as in cinnamon and cascarilla, and in the roots, as in orris and vitivert. Some plants yield more than one odor. Thus the orange has three—one from the flowers, called *neroli*, one from the leaves, called *petit grain*, and another from the rind of the fruit, called *portugal* or *orange*. Perhaps the most striking and surprising method adopted for extracting the perfumes of flowers is that entitled *enfleurage*, wherein the flowers are simply planted in grease trays and allowed to remain until all of their delicate perfume has been abstracted and imparted to the oil or fat in which they are immersed, fresh flowers being added until the fat has become saturated with the aroma of the plant.

The amazing extent of this industry may be gathered from the following statistics, which represent the consumption of flowers at Nice alone, one of the most favorably situated of the perfume manufactories:

Flowers.	Pounds.	Value.
Orange	3,000,000	$300,000
Rose	1,000,000	75,000
Jasmine	250,000	50,000
Violet	100,000	35,000
Cassie	150,000	50,000
Tuberose	50,000	25,000

The celebrated *attar of rose* is made in Turkey and India, where very extensive rose farms are situated, as at Adrianople, Uslak, and Ghazipoor.

Among the numerous perfuming materials used, the following appear to deserve mention in a cursory notice, as the most interesting in their associations, or from the singular fact that, while recognized as perfumes, they are not cultivated for the extraction of their aroma, but simply imitated by suitable compounds.

Ambergris is a secretion of the sperm whale. It is found floating on the sea along the coasts of China, Japan, and Greenland, and for a long time was thought to be fossil amber, from which its name is derived (ambergris), gray amber. Mr. Cristiani remarks that, while not possessing an agreeable odor itself, it imparts, with other perfumes, a remarkable fragrance.

Heliotrope, though immensely popular as a perfume, is imitated by perfumers by a mixture of rose and vanilla, not being expressly cultivated for the purpose of extracting its perfume.

Honeysuckle is another perfume imitated by the perfumer, and deservedly popular.

Lavender is grown extensively in England and France, and its oil is extracted by distillation, the English product being much superior.

The *Lily*, the *Magnolia*, the *Pea*, are all successfully imitated, and it is doubtful whether their admirers ever suspect that they are not enjoying the fragrance of the flowers themselves.

Musk, the powerful odor which evokes so much disgust among some, is invaluable to the perfumer, entering into many preparations. It is a secretion of an abdominal gland in the musk deer. The best quality comes from Tonquin. It is an unctuous substance, reddish brown in color, with a powerful and penetrating smell, which, ameliorated by combination with other odors, forms admirable compounds.

The *Rose* affords the perfumer his most valuable material for the preparation of innumerable extracts and bouquets, while the dried leaves enter into powders and pastilles.

The *Vanilla* is the bean of a handsome vine, and, made into a tincture, it enters into a great number of extracts. It grows in Mexico.

The *Violet* is the most expensive of all flower perfumes, from the smallness of the flower, but it furnishes the most exquisite fragrance, and is justly sought for with avidity. Large farms are devoted to its cultivation at Nice and Florence.

We have just touched, under the guidance of Mr. Cristiani, this wide field of technical research. The subject is one of the most entertaining interest, and one which most of the readers of this paper will realize as extremely novel.

LOUISIANA SUGAR.

ACCORDING to the last report of the Commissioner of Internal Revenue, the following was the production for the year 1892-93 of sugar of all kinds, according to reports and estimates:

	Pounds.	
Cane sugar:		
Louisiana	445,854,797	
Mississippi	3,043	
Texas	9,068,077	
Florida	215,464	
		455,141,481
Beet sugar:		
California	22,801,288	
Nebraska	3,808,500	
Utah	1,473,500	
		27,083,288
Sorghum sugar:		
Kansas		1,026,100
Maple sugar (estimated)		32,000,000
Total production in the U. S.		515,250,796

SUGAR FROM SUGAR CANE.

There were 618 producers of sugar from cane licensed in the district of Louisiana (including one in the State of Mississippi) during the past year, 16 in Florida, and 16 in Texas; total, 650.

The total quantity of acres of cane ground and made into sugar, according to the figures furnished this office, was as follows:

District of Louisiana	180,645
Third district of Texas	4,652
District of Florida	68
Total	185,365
Quantity reserved for seed	44,287
Quantity under cultivation	229,652

The acreage of cane under cultivation for the coming crop, as reported by applicants for license, is as follows:

District of Louisiana	281,667½
Third district of Texas	7,060
Florida	1,213
Total	289,940½
Quantity to be reserved for seed	36,112
Quantity to be utilized for sugar production	253,828½

There is also a quantity of cane under cultivation by persons who take out no license to produce sugar, but sell cane or sirup produced therefrom to licensed sugar producers not included in the above statement, making probably 10,000 acres additional.

The operation of the law in relation to the bounty on sugar has had the effect so far as cane sugar is concerned to increase the production and to lessen the number of sugar factories or licensed producers.

In the district of Louisiana, where cane sugar is principally made, there were during the first season in which the law was in operation, that of 1891-92, 697 producers licensed to manufacture sugar, and the product of that period aggregated 357,875,557 pounds.

The number of producers licensed during the season of 1892-93 was 618, and the amount of sugar produced aggregated 445,857,840 pounds, an increase of 87,982,283 pounds, notwithstanding a reduction of over 11 per cent. in the number of licensed producers.

The number licensed to manufacture sugar in that district during the present fiscal year is 552. There will undoubtedly be a large increase in production over that of last year, probably 20 per cent., unless

some unusual accident, such as an early frost, should supervene.

The average price paid for cane purchased for sugar manufacture in Louisiana is said to be $4 per ton delivered at the nearest railroad station, as against $2.50 and $3 per ton in former years delivered at the factory. In some instances contracts are made on the basis of the amount of sugar that the cane will produce, one-half the product in sugar being allotted to the factory and one-half to the cane cultivator. In some localities it is the custom, in addition to a specific price per ton, to allow a certain per cent. increase in the event that the extraction exceeds a certain limit.

It is estimated that $2,000,000 have been invested in Louisiana in improved machinery for making sugar since the beginning of the present year, the full effect of which will not be seen and appreciated until the conclusion of the coming season. These changes in the machinery of sugar factories result in a more economical manufacture of sugar and indicate a gradual departure from the primitive and more wasteful methods formerly in use.

Although there were 618 licensed sugar producers in the district of Louisiana during the season of 1892-93, only 569 made sugar, of which 295 used the vacuum pan process of manufacture, 272 the open kettle process and 2 used both methods.

Of the 552 sugar producers licensed in the district of Louisiana for the current year, 299 gave notice that they intend to use the vacuum pan process of manufacture, either at the home factories or at factories not owned or operated by themselves, and 250 intend to use the open kettle process or open steam train. Three intend to use both methods, making part of their sugar by open kettle process and part by the vacuum pan and centrifugals.

The methods of evaporation are as follows: First, by the use of open kettles, over a direct fire, from two to six kettles being used. Starting from the mill, the juice is carried from the first kettle into a second, and then into a third kettle as it increases in density through evaporation until it becomes sirup of about 25 degrees Baume before it reaches the last kettle or strike pan, where it is further boiled until it shows signs of crystallization, when it is removed to cooling troughs for granulation and afterward to hogsheads with purging holes for drainage. When sufficiently purged of molasses, the product enters the market as open-kettle sugar. Second, with the process of steam train, open metal tanks with steam coils are used instead of kettles and direct heat (seldom more than three tanks are used with separate strike pans). The juice leaving the clarifiers enters the first evaporator, and as it increases in density is carried into the second, and then into the third evaporator, from which it is pumped into the strike pan at about 25 degrees Baume and boiled by further use of the coils until it shows further signs of crystallization, when it is removed to coolers and treated as open-kettle sugars. Many producers using steam trains granulate their sugar by vacuum pans and centrifugals and make first and second instead of open kettle sugar; again, many open kettle producers have separate strike pans with steam coils, and certain others boil to sirup of 25 degrees Baume and granulate by vacuum pan and centrifugals.

The third and last method of evaporation by vacuum, single, double, and triple effect, is alike in some respects to the steam train, except that the receptacles or evaporators are covered and air tight with vaccum produced through pumps, causing the juice to boil and evaporation to take place at a lower temperature, 120 to 170 degrees F., against 212 F. or over in open pans. Steam coils are also used here. The vapor of the first effect becomes the heating power of the second, and so continues through the several evaporators. This method also brings sirup to the density of 25 to 26 degrees Baume when it enters the vacuum pan for granulation.

In the classification of the sugar producers, for office purposes, there are two kinds of vacuum pan and open kettle producers; namely, those who make their sugar at factories owned and operated by themselves and those who have their sugar made at factories not owned or operated by themselves. Some producers make sirup at one factory which they own and have it granulated at another factory, often a central factory.

WHERE COTTONSEED OIL GOES.

THE disposal of the immense output of cottonseed oil will interest those who are not familiar with this rapidly growing industry and the many uses that have been found for this most useful of all vegetable oils.

The question is frequently asked, "What is cottonseed oil used for?" Last year there were probably 1,250,000 tons of seed crushed. Out of this seed there were obtained about 1,000,000 barrels of oil.

At Chicago not less than 300,000 barrels are used for making lard. At St. Louis, Kansas City, and Omaha about 200,000 barrels are used in making lard.

The lard is made by mixing beef suet with cottonseed oil, the degree of hardness of the product being determined by the relative proportions of the oil and suet. It is notable that in much of the lard there is no hog product at all.

About 20,000 barrels are used on the coast of Maine to pack sardines.

Probably 50,000 to 100,000 barrels are used by the soap makers for making toilet soaps.

Some 200,000 to 300,000 barrels go to Rotterdam, Holland, for making butter. Large quantities go to Marseilles, France; Trieste, Austria; and various points on the Mediterranean coast, especially in Italy, for mixing with olive oil.

The poorer grades are used for illuminating purposes in mines, as a lubricant in cutting threads on pipes and bolts, and other purposes.

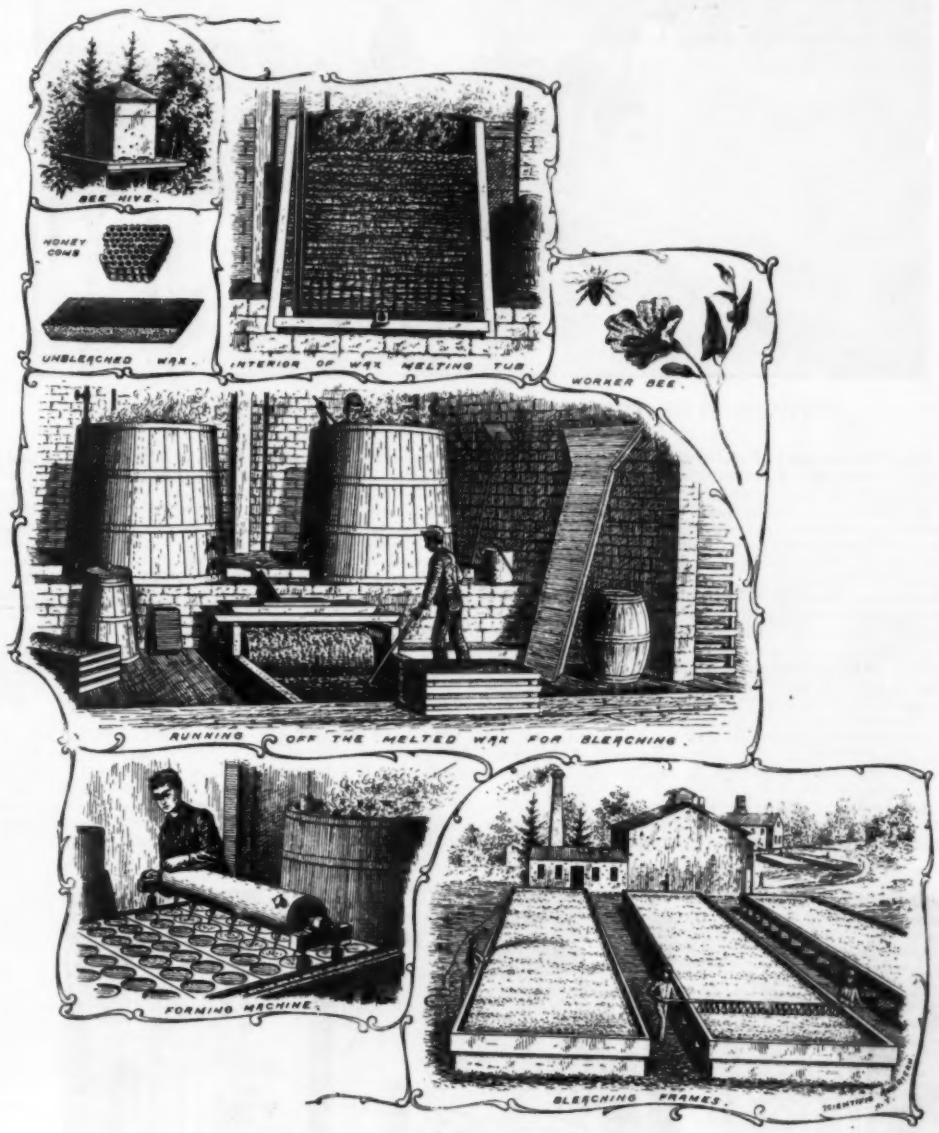
It is not a good lubricating oil, because it contains too much gum. Much money has been expended trying to find a process of refining that will eliminate the gum.

Of late years much oil has been shipped to Mexico and South America. In these Latin countries it is used as a cooking grease, without the necessity of disguising it as lard by using beef suet with it. In fact, most of the people of the earth prefer a clean vegetable oil for cooking to American fats. The Anglo-Saxons and Germans are notable exceptions.

Its use in an unadulterated condition in America as a cooking grease is rapidly increasing, especially in Texas and New England. All the restaurants in Houston, Galveston, and other Southwestern cities, and in Boston, Providence and other New England cities, keep pure refined cotton oil on hand at all times. In Boston the physicians uniformly prescribe food cooked in cotton oil as a remedy for indigestion, and the idea has grown very popular, especially in Boston and the adjacent towns and cities.—*Charlotte Observer.*

A BEESWAX BLEACHERY.

BEESWAX is supposed to come from the stomach of the bee in the form of scales and carried to the mouth with the legs, where a frothy liquor is added to it, causing it to become plastic. In this state it is formed into the cells or comb, in which the bees deposit their honey. The combs are formed in hives built for that purpose, some of which contain colonies of bees numbering from 10,000 to 40,000. Where the climate is warm most of the year round, each hive will average between 350 and 400 pounds of honey. The greatest honey and wax producing States are New York, California, Ohio, Indiana, Illinois, Wisconsin, Michigan, Kentucky, North Carolina, and Dakota. These States produce about 800,000 pounds of beeswax yearly. About twenty pounds of honey are required to produce one pound of wax. Large quantities of wax are imported to this country in cakes of twenty-five and fifty pounds each from Cuba and Africa. It comes in two colors, light yellow and dark brown.



A BEESWAX BLEACHERY.

Bees that gather most of their honey from grape and tobacco flowers produce the dark colored wax, which is hard to bleach. That produced from clover, buckwheat, etc., is light colored and bleaches easily. The bleached wax is used mostly by sperm candle manufacturers, wax flower makers, druggists, and in the manufacture of carbon paper. The large cakes are first broken up into small pieces and put into a large circular tub or vat made of cedar. This tub is about five feet in height and about three feet in diameter. Across the bottom of the tub are two square hollow wooden pipes, one crossing the other at the center, the tops of which are perforated with a number of holes. Placed into the end of one of these pipes is a perpendicular wooden pipe, which is connected at the top to a brass steam pipe.

About 1,500 pounds of the wax is placed in the tub and enough water poured on to it to swim it well. From forty-five to sixty pounds of steam is then turned on, which rushes down to the perforated pipes and is forced up through the holes and distributed through the wax, which, in about three hours, becomes thoroughly melted, the dirt and grit, if any, sinking to the bottom. It is then drawn from the tub and run through a sieve, where it falls down on to a revolving wooden wheel or roller, about 4½ feet in length and 18 inches in diameter. The bottom of this roller rests in a bed of water about 18 inches in depth and about 6 feet in length, the temperature of which is about 70°. As the melted wax leaves the sieve it strikes or falls on the top of the wooden wheel in small pieces or ribbons, sticking fast and becoming instantly chilled.

This roller makes about sixty-four revolutions per minute, the wax dropping off the instant it comes in contact with the water. The material is then taken out of the water bed, by means of wooden forks, and placed in boxes and carried out to the bleaching frames. These frames are made of wood, about 100 feet in length, 14 feet in width, and about 8 inches in depth, and raised 3 feet from the ground. About 1,000 pounds of wax is placed on each frame and left out day and night for the sun to bleach for four weeks. It is sprinkled with water four to five times daily, to keep the summer sun from melting it, as the temperature reaches as high as 120°. Once a day a 64-pronged wooden rake is drawn back and forth through the material, which turns it over, allowing the sun to act on every particle. The wax when first taken out to bleach is yellow. After four weeks' exposure in the sun it becomes a creamy white. It is then gathered up and taken back to the tubs and melted over again, going over the same operation and out again to the bleaching frames, to remain out two weeks longer, with the same sprinkling and raking operation. This second bleaching turns the wax almost to a snow white, and it is ready to be formed into cakes for the market.

About 600 pounds is then melted up at a time in a tub and drawn off to be made into cakes as needed. These cakes are made by running melted wax from a horizontal movable copper cylinder into circular moulds. These moulds are of heavy tin, 4 inches in diameter and about one-quarter inch in depth, and are placed one after another on a long table, the sides of which are fitted up with tracks, over which the movable cylinder can be drawn back and forth. This cylinder is 10 inches in diameter, 5 feet in length, and double. The outer cylinder contains hot water, which surrounds the inner one, containing about fifteen pounds of melted wax. The hot water and wax are poured into the cylinders by means of capped tubes at each end. Projecting from the outside of cylinder and connecting with the inner cylinder are a number of small hollow tubes, through which, when the attendant turns the cylinder over, the wax runs out into the moulds. As soon as the moulds are filled the cylinder is drawn back again and pushed forward to the next set of moulds, the operation being repeated until the moulds are all filled. To keep the wax from cooling, the hot water is poured when cooled, and fresh added after every ninety pounds of wax has been drawn off. The moulded wax becomes cool in about one hour, and it is packed into boxes and ready for market. The sketches were taken from the plant of Theodor Leonhard, Paterson, N. J.

THE EXPLOITATION OF TURF AT PAS-DE-JEU (DEUX-SEVRES).

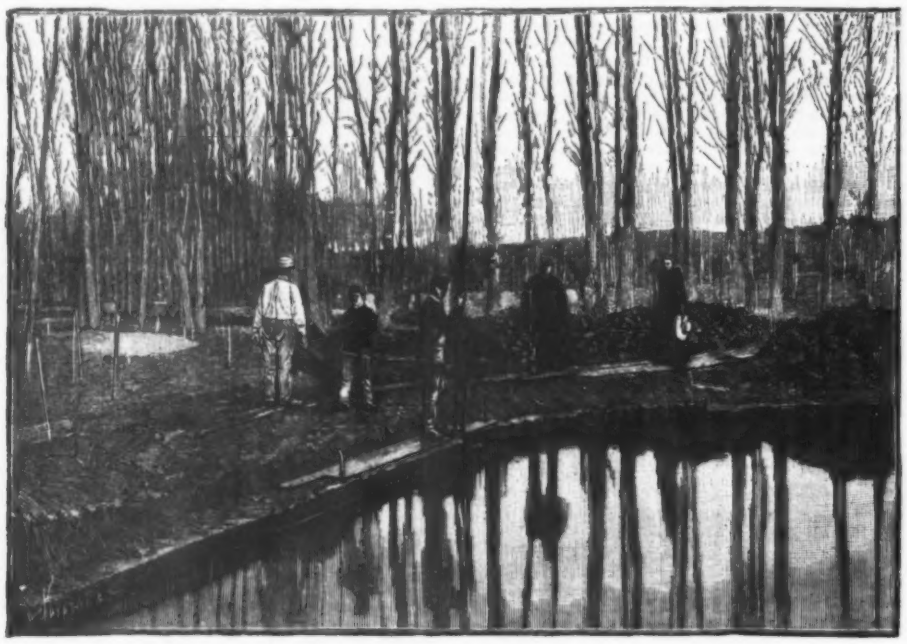
THIS year the dearth of forage has directed the attention of agriculturists to the use of turf. For the litter of thoroughbred horses there has long been used a material called Dutch turf, brought from Holland at great expense. It is a fibrous substance of a yellowish color, which, exported in large 150 kilogramme bales, somewhat resembles large packages of rags. What does it consist of? What we have seen appears to contain only plants on the surface—stems of *Dicranum* and *Polytrichum*, and of *Scirpus*, *Carex*, etc. Spread out and well stirred, it constitutes quite a soft bedding, of an absorbing power greater than that of straw. The use that is at present made of turf for litter offers a capital importance, and we believe it of interest to say a few words about an exploitation of some extent carried on in France—that of Pas-de-Jeu, in the department of Deux-Sevres.

The turf of Pas-de-Jeu, extracted under water, dried in the sun and crushed into coarse powder, is extremely absorbent, antiseptic and hygienic. Provided it be well stirred and well preserved, four to six hectoliters weighing 50 kilogrammes will remain clean from one to two months under a horse of ordinary stature, and afterward furnish a very rich manure under a smaller bulk than ordinary farm dung. In fact, with the turf of Pas-de-Jeu there is no flow of liquid manure in the stalls of the animals. The fertilizing part of the dung has been stored up, so to speak, by the turf, without loss to agriculture.

The subsoil and all the surrounding part of the valley of the Dive being calcareous, it is not necessary to seek therein any trace of silicious plants. The primitive other. This agglomeration of mosses has exactly the appearance of the Dutch turf, but these are surface plants. At Pas-de-Jeu, the formation of the marsh is finished, especially since the canal has been dug from Dive to Saumur. The surface, formed by a fine black earth without stones or pebbles, is covered with meadow grass, along with numerous poplars of extraordinary vigor.

In order to exploit the turf, a certain thickness (about 30 centimeters) is first removed from the surface, and by means of a special instrument called a trenching spade, a stratum of turf is cut up to the level of the water. The water is found at less than a meter in depth. It is at this moment that use is made of the large trenching spade invented in Picardy in the last century. It consists of a right-angled three-sided box about 1·5 meter in length, formed of a light open framework of sheet iron, the whole attached to a handle of oak wood of a length of 5 meters or more and that can be increased. The bottom of the instrument has a cutting edge. Besides, at the top, near the handle, upon the third and open side there is a small flexible tongue of sheet iron designed to hold the long piece of turfy substance at the moment that it is detached from the bottom. As the turf thus accumulated at the bottom of the water through ages is a soft spongy substance unmixed with sand or gravel, the instrument penetrates it with great facility.

The long parallelopipedon of turf thus extracted is laid upon terra firma, cut into three sections and placed upon a wheelbarrow. These pieces or briquettes are then carried to a short distance and placed in piles of twenty-one each. These briquettes, thoroughly hardened by the sun and crushed by a special instrument, form the litter-turf.



EXTRACTION OF TURF FROM BOURCANI POND, AT PAS-DE-JEU.

Our engraving represents a laborer manipulating his instrument, which he is preparing to plunge into the peat bed in order to extract a briquette of turf. Behind him may be seen a boy helper holding a briquette in his hand. Alongside of him is the barrow man, who is in the act of carrying away the briquettes that he is to pile up in the drier.

The Pas-de-Jeu turf is genuine turf in every geological acceptation of the word. It has gradually filled to repletion the ancient bottom of the valley of the Dive, at the northwest point of contact of the departments of Deux-Sevres and Vienne.

Its very nature and its chemical composition make of it a fuel, a fertilizer and an essentially hygienic litter. In fact, it possesses a great absorbing power which permits it, in neutralizing bad odors, to retain the liquid portions of animal dejections. It is especially as a disinfectant and antiseptic that it is destined to render in stables the greatest services to agriculture.

It has, besides, the important advantage of being a French product of low price, and of furnishing an extremely rich fertilizer after being used as litter.

In order to derive the best results from it, it is necessary to place under oxen, horses or other animals of large size, from four to six bags of the pulverized substance. The bags weigh 50 kilogrammes.

This litter, kept in good order by a daily stirring, will last from six weeks to two months.—*La Nature.*

THE EXHIBIT OF THE UNITED STATES GOVERNMENT AT CHICAGO.

THE exhibit made by the United States government is certainly one of the most interesting, if not the most interesting, of all those contained in the vast buildings of the World's Fair. The defect of great international expositions, and of the Chicago Exposition in particular, is the dispersion of the objects of the same nature or relating to the same subject. Each one exhibits according to his taste and his interests, which are often entirely opposed to those of his neighbor, and the Exposition assumes, in definitive, the aspect of a fair rather than of a museum. This does violence to the impresion of the whole, and renders the general study of a given question very difficult.

The organizers of the government exhibit have endeavored to avoid this defect and have fully succeeded. They show the natural productions of the country, and, by way of comparison, the progress made by the American people since the epoch at which Christopher Columbus landed upon *terra nova*, and especially since the declaration of independence a hundred and seventeen years ago. Alongside of the historic objects and restorations may be seen the most improved modern methods. These object lessons offer a great interest.

The objects exhibited in the Government building may be separated into two distinct parts, one of them relating to the soil, its curiosities and its productions, and the other designed to make known the different services of the great American republic: War, Agriculture, Justice, Interior, Post Offices, Finances and Affairs of State.

The celebrated Smithsonian Institution and the Washington Museum have sent the most curious objects of their collections. These are clay models of natural size that represent the ancient inhabitants of America, their costumes and their occupations, and collections of birds, animals and insects. These latter merit special mention, for we do not believe that there are any in existence that are better arranged and better adapted to the education of the public. Each species is represented by several individuals of different age and sex, grouped in the attitudes that they assume in a state of liberty, while the necessary accessories make known the surroundings in which they live, the food that they prefer, the form of their nests, burrows, etc. A short description accompanies each group. The visitor can thus learn in a few minutes more than he could by extensive reading. It is very different from the dry nomenclature of certain of our museums. Some of the subjects are of rare beauty. We may mention in particular the walrus, an animal living in Behring's Sea, of which the Eskimos utilize the flesh, skin and oil. The skin, which is of considerable thickness, is utilized especially for polishing.

The center of the building, under the great cupola,

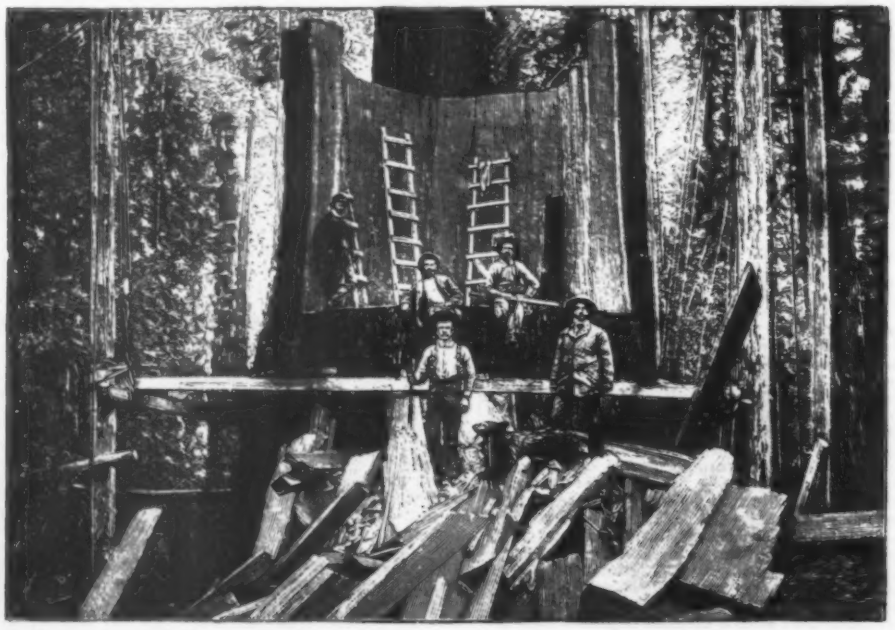


FIG. 1.—OPERATION OF FELLING THE SEQUOIA EXHIBITED AT THE CHICAGO EXPOSITION.

FIG. 2.—TRUNK OF THE SEQUOIA EXHIBITED AT CHICAGO.

marshes have disappeared and have been replaced by meadows. Here are met with no heaths, no sphagnum, nor any of those other mosses which in certain countries form true accumulations. At Bressuire (Deux-Sevres) and at Roche-sur-Yon (Vendee), we sometimes observe in the non-inundated marshes sorts of protuberances that rise above the surface of the earth and that are formed of nothing more than sphagna mixed in groups closely pressed one upon the

is occupied by a portion of the trunk of one of the big trees of California (*Sequoia gigantea*—Fig. 2). These trees, which were discovered in 1852 by Mr. A. T. Boyde, a hunter, soon acquired great celebrity. Their wood, which is very heavy when it is green, becomes much lighter in aging, and is susceptible of a beautiful polish. Their destruction was becoming so rapid, being given that they are no longer capable of reproducing themselves, that the govern-

ment had to take particular measures to prevent their entire disappearance. In order to preserve a specimen of them, it caused the exhibited example to be cut, to which has been given the name of "General Noble." It is 22 feet in diameter, 82 feet in circumference and nearly 30 feet in height, and forms a true cylindrical house, as shown in Fig. 2. It is the largest section of the redwood that has ever been transported. The center has been removed, in order to afford space for a spiral staircase, terminating in a platform from which the visitors can conveniently observe the paintings of the dome. The interior is illuminated by the electric light, and, around the platform, are placed photographs representing the different phases of the felling and transportation of this huge object.

The tree from which it was taken was 300 feet in height, 26 feet in diameter, and 101 feet in circumference at the base. It is one of the smallest specimens of the species. It was selected on account of its regular form. The section was made at 20 feet above the earth. It would have been impossible to transport this annular block in a single piece. So it had to be divided into 46 segments, certain of which weigh more than four tons. Eleven cars were employed for the carriage of it. Fig. 1, reproduced from a photograph, gives an idea of the system employed for the felling, as well as of the size of the tree. Four large poles were raised around the trunk, and a platform was erected at the level of the upper section. The upper part of the tree was cut down, and broke in its fall, and then the work began. A tackle block fixed to the extremity of a gin served to lower the segments. The transportation presented peculiar difficulties. As these trees are found sufficiently tall in the mountains only, it became necessary, in fact, to travel a distance of nearly sixty miles before reaching a railway station. This journey could be effected only by wagons constructed especially for the purpose, to which were harnessed sixteen mules. The felling and carriage to the railway cost alone $7,500.

The Post Office Department exhibits drawings and models representing the old processes of letter carrying in different countries, alongside of a postal car provided with all the recent improvements, and a complete post office. This office is entirely surrounded with glass. It is open to the public, which can thus follow all the operations necessary for assuring the rapid and sure carriage of correspondence. This department exhibits likewise a collection of different postage stamps and of curiosities derived from what the Americans call the "Dead Letter Office."

Alongside of letters not delivered for want of sufficient address (and certain of these addresses are so ingenuous that they would make a collector happy) are observed a number of objects sent through the mail, up to living snakes and others preserved in alcohol! In each case the address has been put upon the object, and sometimes, even, the letter accompanying the sending has been added with the hope that among the visitors some one might be found who would recognize the lost articles and be able to claim them. Alongside of the coins and stamps of the present time are exhibited those that were employed at the time that the thirteen States formed the nucleus of the nation. Not far distant are exhibited the lighthouses and luminous buoys employed in the United States, but which for the most part are of French construction.

Upon a bracket, above delicate and complicated reckoning machines, are exhibited the old election returns of a time when the compilation of the ballots was easier than the throwing out of the votes deposited in the ballot box of a district. One can see all the mechanical calculating arrangements, and four men are employed in running the machines.

Above this space there is suspended one of the largest geographical globes ever constructed. It is twenty-two feet in diameter and makes one revolution per minute. By a skillful arrangement it is lighted internally by electricity, and the water, earth and letters are projected with intensity in different colors when the sphere is revolved.

In the southwest corner is the exhibit of the Secretary of War. From the ceiling are suspended all the flags and standards of the army, with the signals that serve for communicating orders in times of maneuvers. The visitors can see the cannons of old times alongside those of the present, and the pieces of artillery that Lafayette offered the nascent nation in the last century alongside of gigantic modern guns and electric torpedoes. A row of machines run by expert operators make cartridges, firearms and blank arms for the "boys in blue." Wax figures illustrate the different uniforms of the service. Plans, models and photographs make known the great work executed by the army engineers of the country.

The exhibit of fisheries is very complete. The zoological stations, the exploring boats, with their apparatus of observation and the results obtained, the fishing apparatus, from the rude bone hook employed by the Indians up to the most improved fish hook, as well as all the models of nets, harpoons and dredges employed by professionals or amateurs, are represented in these collections.

The section of pisciculture shows us the apparatus for collecting and transporting fishes' eggs and fecundating them, models of hatching apparatus for heavy eggs, of medium or slight density, with eggs in different stages of advancement, from the moment of depositing to that of hatching.

In all these exhibits, numerous drawings and photographs permit of following all the phases of the transformation and the results obtained everywhere where the apparatus were too cumbersome to carry without presenting a sufficient interest. This permits of following exactly the plan of the whole, while at the same time avoiding useless repetitions.

Finally, we shall mention the exhibit made by the Patent Office of the models of apparatus patented in America. Among the enormous number of inventions of which the citizens of free America have desired to guarantee themselves the proprietorship, the selection was not easy. The plan adopted gives this exhibit a peculiar value from a historical point of view. Thus, in the showcase in which is exhibited the first electric telegraph invented (a cumbersome and massive apparatus made almost entirely of wood) are placed thirty models showing the important improvements that have led to the creation of the almost perfect modern apparatus. As the Americans receive all their dispatches by sound, without preserving any trace of the transmission, the printing and autographic apparatus are a revelation for many in the United States. It is to be regretted that alongside of the form that the apparatus possessed at the time of its invention the present practical form of the same apparatus is not represented. Those inventors, and they are legion, who think that it suffices to have the principle of an invention in order to make it a success, and gain glory and wealth therefrom, would have found salutary instruction. They would have seen how much work it requires in order to practically realize inventions, even the best. It is difficult, for example, to recognize in the first Hughes telegraphic apparatus the present apparatus under the form that Mr. Fremont has given it. And it is the same way in many other cases.

Nearly 3,000 models are exhibited! They relate to gas, air, steam and electric motors, to machines for working wood and metals, to combing, carding and weaving machines, to arms, to machine tools, to sewing machines, etc. All the models selected are grouped in such a way as to completely illustrate the development of a same idea.

The government exhibit is completed by a meteorological bureau, with registering apparatus, a life saving station, and a naval exhibit contained in a reproduction of a ship of war constructed expressly for the Chicago Fair.—*La Nature.*

THE SONNEBERG TOY CHARIOT.

THE SONNEBERG TOY CHARIOT.

THE exhibit of Germany at the Fair was very comprehensive, all of the great industries being adequately represented. In toys Germany leads the world, and Nuremberg has been called the toy shop of Europe. At the Fair the two most remarkable exhibits of toys were made by the town of Sonneberg and by the cities of Nuremberg-Furth, who combined their exhibits, as they are situated only four miles apart. Sonneberg is a town of Saxe-Meiningen and is situated twelve miles northeast of Coburg. Nearly the whole population of Sonneberg, which numbers over seven thousand, is engaged in the manufacture of toys, musical instruments and wooden ware. The dolls of Sonneberg have a world-wide reputation, and many thousands of the flaxen-haired little Gretchens delight the children of America every Christmas. The Sonneberg chariot in the German section, Manufactures building, which we illustrate, was a carved and gilded creation filled with dolls and delightful animals of the higher grade. On top is St. Nicholas, with traditional pack and beard, while just below a tidy German nurse maid is seen with her charge. This chariot was a never-ending source of delight to the children. The drawing, for which we are indebted to the *Illustrirte Zeitung*, was made by the German artist, E. Limmer.

A NEW SYSTEM OF VEHICLES.

ALL of our readers are acquainted with the inclined plane horse mills that have been so extensively used in recent years. An inventor has conceived the idea of applying this apparatus to the propulsion of all kinds of vehicles upon roadways. The principal advantage that he calculates on deriving from this arrangement is that the horse, being situated in a box closed on every side, there will be no fear of those frequent accidents caused by fright. Moreover, as the transmission of the work produced by the horse to the vehicle is effected through the intermedium of a gearing, the pilot can, at the least warning, throw the mill out of gear and tighten a brake, thus producing a much quicker stoppage than can be effected in the present style of vehicles.

Our engraving will allow the operation of the system to be understood.

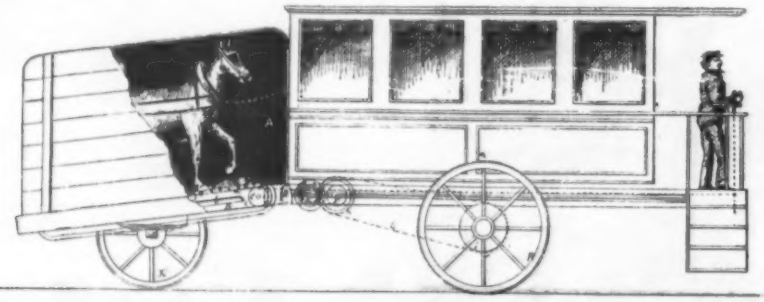
The horse stands in a box, A, whose inclined floor consists of an endless chain, B, passing over two cylinders, C, situated at the two extremities of the box and supported throughout its length by rollers, *a*, revolving over tracks, *b*. The axis of the front cylinder carries along, through the intermedium of the bevel gearings, *c c*, of the shaft, D, and of the gearings, *d e*, the shaft, E, which revolves in one direction or the other, according as we throw into gear with the wheel, *d*, one or the other of the pinions, *e*, both loose upon the shaft.

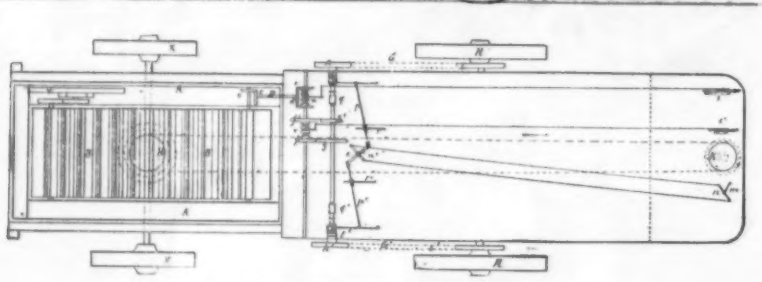
Two wheels, *f* and f_1, keyed upon this shaft and gearing with two others, *g* and g_1, keyed upon the shaft, F, transmit the motion to this latter with different speeds, according as we have thrown into gear the pair of wheels, *f g*, or the pair, f_1 or g_1.

Finally, this shaft, F, actuates the wheels, R, of the vehicle by means of the pitch chains, G and G_1, passing over the toothed wheels, *h i* and h_1, i_1. Coupling boxes, *l* and l_1, permit of isolating one of the wheels at a given moment, this being indispensable in order that the vehicle may be able to turn.

The axle of the hind wheels, X X, is mounted upon a bolster pin, and the motion of turning out is produced by acting upon the toothed disk, H, by means of a chain passing over the wheel, K, whose axis carries a hand wheel which is maneuvered by the pilot.

The two gearings, *l* and l_1, can be thrown out of





NEW SYSTEM OF VEHICLES.

gear simultaneously by turning the crank, *m*, whose axis carries a side lever, *n*, connected by rods with the lever, n_1, which is connected with the lever, *o*, that acts upon the connecting rods, *p* and p_1, controlling the two coupling boxes. These latter are moved back to their initial position by springs or by counterpoises, *q* q_1.

The ungearing of one or the other of the gearings, *l* l_1, takes place automatically when the bolster pin of the hind axle is acted upon. To this effect, the chain controlling the toothed disk, H, acts, for example, upon the bent lever, *r*, which carries along the connecting rod, *p*. As the eye that serves to connect the latter with the lever, *o*, is elongated, the connecting rod, p_1, is not influenced. In this case, the bent lever, r_1, does not act any more upon the rod, p_1. The control of the gearings, *u* and *v*, of the shaft, E, is effected by means of rods or wires ending at the hand levers, *s* and s_1.

Finally, the apparatus is provided with a fly wheel (not shown in the engraving), around which winds a brake band, controlled likewise by the pilot, and which serves to stop the movable inclined plane in case of accident.—*Les Inventions Nouvelles.*

GAS MOTORS IN GERMANY.

THE following is from the official report to the State Department by our consul-general to Germany, Mr. Frank H. Mason:

Prominent among the economies which have been introduced during recent years in Germany is the use of gas motors in place of steam engines in all the smaller forms of manufacture where the motive force required does not exceed 75 to 100 horse power. At the Frankfort Electrical Exposition of 1891 most of the dynamos were driven by gas and caloric engines, and the display of these motors at that time was almost as varied and interesting to the general public as that of the electrical apparatus to which they were technically subsidiary.

There were in operation at that time throughout Germany about 18,000 gas motors, with an aggregate motive force of 60,000 horse power. Since then the gradual cheapening of gas and the rapid extension of electrical lighting and electrolysis have combined to increase very rapidly the use of gas motors, the effectiveness and economy of which were so brilliantly demonstrated at the Frankfort Exposition. No statistics are available to show the precise number that are at present in use, but, as the two principal makers of gas engines in Germany have alone made and delivered during the past two years 1,950 motors, it may fairly be inferred that the number in actual service in this country is not far short of 24,000 or 25,000.

Meanwhile the progress that has been made in improving the machines and increasing their economy has been quite remarkable. The first gas motors, which were exhibited and used experimentally about 1868, were fatally extravagant. The Lenoir machine, which was the best model known to Germany as late as 1861, used—according to a recent statement in *Kuhlow's Trade Review*—1,235 cubic feet of gas per horse power per hour, whereas the motors now in use consume only 28 feet per horse power per hour in small machines, and in large sizes as low as 23·75 feet; so that 21·2 cubic feet of gas per hour will run an incandescent lamp of 16 candle power, and this proportion is said to have been reduced in large plants which employ motors of 500 horse power and more to 17·6 cubic feet of gas per horse power per hour.

How economical such a motive power must be for all the smaller forms of manufacture, and especially for electrical lighting by isolated plants, will be apparent from the following tabular statement of the price per 1,000 cubic feet of gas which prevails at present in the principal cities of Germany:

Altona, Bremen and Mayence	$1 36
Brefeld (with discount to large consumers)	1 32
Brunswick, Bonn and Strassburg (without discount)	1 21
Magdeburg, Leipsic and Breslau (with discount)	1 21
Barmen (with discount)	1 19
Dantzic and Dresden	1 14
Berlin and Konigsberg (without discount)	1 09
Cassel, Dortmund, Elberfeld and Hanover (with discount)	1 09
Frankfort (with discount)	1 07
Stettin, Essen and Cologne	1 02
Bochum	95

In some of the above named cities gas is made and furnished by the municipality, in others by private companies chartered and managed similarly to private gas companies in the United States. In Frankfort the field is occupied by two companies—one English, the other German—which have parallel mains on all principal streets and supply for the above-stated price gas of uniformly excellent quality. When it is remembered that the coal for the manufacture of gas in this city is brought from England and the Ruhr district of Westphalia, it will be apparent that for two rival companies to prosper in a city of 180,000 inhabitants by selling gas at $1.07 per thousand it must require good management and the employment of the most improved methods. As a matter of fact, the cheapness of gas here, as elsewhere in Germany, is the direct result of the skill and care with which all the subsidiary products of coal distillation—tar, ammonia, etc.—are saved and utilized.

[Continued from SUPPLEMENT, No. 941, page 15034.]

FLAME.*

By Prof. ARTHUR SMITHELLS.

KEEPING to our list, we ought next to deal with the combustible hydrogen sulphide or sulphureted hydrogen. This gas, you remember, is composed of two separately combustible elements, each burning in one stage. The flame is, as you might expect, two-coned, but I will not dwell upon this case—partly because it is not yet fully worked out, and partly because any prolonged experimenting with this gas would, I feel sure, be resented even by the most indulgent audience.

I am obliged, therefore, to pass to compounds of carbon and hydrogen, in which there are not only two combustible elements, but one of them, as we have seen, combustible in two chemical stages. Here we have an almost unlimited choice of materials, for we come among the combustibles which ordinarily supply us with light. I shall, for the sake of convenience, use coal gas. This is really a very complex combustible, consisting one half of hydrogen, the other half of at least a dozen different compounds of carbon and hydrogen. But experience has shown that the chemical phenomena attending its combustion are quite of the same character as those to be observed with a single compound of hydrogen and carbon.

It will, I imagine, be scarcely necessary for me to point out the various parts which are to be seen in the flame of a candle or of coal gas. There is on the diagram (Fig. 2, *c*) before you the picture of a somewhat small coal gas flame, produced at a circular orifice. It is, of course, enormously enlarged in the diagram. Four distinct parts are to be recognized. First, the central and darkest part; this contains the unburnt gas, just as we saw in the case of the carbon monoxide flame. Perhaps it is wrong to speak of this at all as part of the flame, for it is really a region of no flame. At the base of the flame are two blue strips embracing the lower portion of the flame. This appearance you will understand results from the mode in which we view the flame. The strips are really due to a sheath which goes right round the flame like an uninterrupted calyx. It looks bright where we view it edgewise. When we look through, as in the middle of the diagram, it is very pale indeed. Next we have to notice the bright yellow patch, so bright in the reality as to mask the other parts. Though it looks bright and dense, it is merely a hollow sheath. Lastly, there is surrounding the whole flame a pale mantle of flame of very slight luminosity, and of an almost indescribable tint, which perhaps we may call lilac. These parts are discernible in all ordinary flames. They do not always occupy the same relative space. In the flame given by a good gas burner the yellow part is made by intention as large as possible; in the flame of a piece of string or a spirit lamp you will see the outer investing mantle very distinctly developed.

If we are to understand flame, then, we must find an intelligible explanation of the existence of these distinct parts of its anatomy. One important point we can settle at once. An ordinary flame owes its differentiated structure to the slowness with which it gets the oxygen necessary for combustion. If there is an immediate and sufficient supply of air, the characteristic structure disappears. This we can secure by making the stream of gas sufficiently rapid. I have here a steel cylinder containing coal gas at very high pressure. If I allow the gas to escape slowly, we get a flame in which we should find the ordinary parts. But if now I allow the gas to issue rapidly, the admixture with air is so rapid, and, as you see, we have a pale flame quite undifferentiated in structure. We reach the same result by introducing a strong current of air into an ordinary flame, as in the blast blowpipe. The flame, you see, is then homogeneous, as in the previous case.

We see then that the structure of an ordinary gas flame is largely dependent upon the slowness with which the gas gets the air necessary for combustion. There is still one other evidence of this. It is obvious that a very small flame will have a much better chance of getting its oxygen quickly than a larger flame. It is, I am sure, within every one's knowledge that a very tiny gas flame is blue, and as a matter of fact, we can learn a great deal about flame structure by carefully watching the development of a very small flame. I am going to show you on the screen a series of photographs of actual flames. The photographs have been tinted as faithfully as possible.

The first slide (Fig. 3, *a*) shows a tiny gas flame burning at the end of a glass tube; it consists of a bright blue cone surrounded by a fainter one. Both are quite continuous. By putting in another slide, and using the "dissolving view" arrangement of the lantern, I will show you the effect of turning on the gas. The flame (Fig. 3, *b*) you see is larger, and now is observed a third region in the flame—namely, a patch of bright yellow at the tip. The original cones are still there, but are slightly interrupted at their apices. Turning on more gas, the flame (Fig. 3, *c*) again enlarges, the yellow patch increases in size, and the original cones are further broken into. But you see the yellow patch is indented at points corresponding to the inner cone, which, as it seems, is striving to maintain its integrity. Turning on still more gas, we have now a great preponderance of yellow, the original blue cone is reduced to mere vestiges, and the outer cone forms a faint surrounding to the whole flame (Fig. 3, *d*). This is flame as we ordinarily know it. I wish now to show you another series of changes. We must suppose the gas supply fixed, and the photographs I will show represent the changes which take place in the flame when air is gradually added beforehand to the coal gas. The supply of coal gas is, I repeat, the same in all cases. The first change seen is, you will notice, that the yellow patch diminishes in extent (Fig. 3, *e*). If I add more air, it diminishes still more, and the inner cone is growing in distinctness (Fig. 3, *f*). If I add a trifle more air, the yellow patch disappears altogether, and we have now complete and distinct inner and outer cones (Fig. 3, *g*). I think you will admit that these two sets of photographs show a close correspondence, and you can see it more plainly if I throw them on to the screen in a group. There is really nothing surprising in this similarity. The smallest gas flame has obviously the best chance of getting air, and when it gets enough, it burns in a two-coned flame. The same effect is reached by adding air to the gas before it is burned. If we have a larger gas flame it has, of course, less chance of getting its oxygen rapidly, and we see that in whatever way we starve the flame of oxygen, we lose the simple structure, and come upon the yellow patch.

Now, when we come to inquire into the chemical changes occurring in such a flame, we may, I think, feel confident that the chemical actions which determine the existence of the blue cone and the outer cone are the same, whether these cones are complete, as in a small flame, or fragmentary, as in a larger one.

If that is so, we can soon make progress, for, as I have shown you, we can easily separate these cones and find what is going on in each. I again use the cone-separating apparatus. First we have an ordinary luminous gas flame at the top of the outer tube. I pass in air, the flame loses luminosity, and rapidly becomes an ordinary two-coned Bunsen flame. I push the air supply further; the inner cone enters the tube, and descends until it rests on the end of the inner tube. The two cones of a hydrocarbon flame are thus widely separated; we can aspirate a sample of the gases, and see what changes have taken place in the first region

* An evening discourse to the British Association at the Nottingham meeting, September 15, 1893. From *Nature*.

of combustion. The result is one that we might await with curiosity, for we have now a competition. There are both carbon and hydrogen to burn, and not enough oxygen to burn both; the question is, which will have the preference? I think I may say that the offhand opinion of any chemist who has not had his attention drawn specially to this point would be that the hydrogen would easily have the preference. But, as a matter of fact, this question was settled long ago by Dalton, and in the opposite sense, and in the present case analysis would confirm this conclusion. If we analyzed the gases, we should find that all the carbon is burnt in the first cone, while a considerable part of the hydrogen passes through unburnt. The change is not quite so simple as these words might imply, as you will see from the actual figures of analysis.

ANALYSIS OF INTER-CONAL GASES FROM A COAL GAS AIR FLAME.

Carbon monoxide	8·7	17·9 combustible gases.	
Hydrogen	9·2		
Carbon dioxide	4·1	20·1 burnt gases.	
Water	16·0		
Nitrogen	62·0		
	100·0		
Amount of air used	78·5	Oxygen	16·5
		Nitrogen	62·0
Amount of air still needed	42·9	Oxygen	9·0
		Nitrogen	33·9

About two-thirds of the carbon is burnt to form carbon monoxide, one-third to form carbon dioxide, while rather less than two-thirds of the hydrogen is burnt, and more than one-third remains altogether unburnt. We need not dwell on the details, especially as the analysis of the gases was made after they had cooled. The four gases—carbon monoxide, carbon dioxide, steam, and hydrogen—act upon one, as a matter of fact, while they are cooling down, and the distribution of the oxygen that we find in our analysis of the cold gas is not precisely that which exists in the gases as they just leave the inner cone. We shall only draw a general inference, and it is one that has been recently verified in a very complete manner by Prof. Dixon and his pupils. This inference is simply that the carbon in the inner cone is for the most part burnt to carbon monoxide, and that the hydrogen to a considerable extent is set free. So much then for the inner cone. The outer cone is due simply to the burning of the carbon monoxide and hydrogen which escape from the inner cone. When they meet with oxygen in the free air their combustion is completed. We are now in possession of the explanation of the two-coned gas air flame. Applying this to the tiny gas flame to which no air has been previously added, we see that the inner cone will be formed where the air has penetrated the gas sufficiently to produce such a gaseous mixture as we had in the lower cone of our separator. The gases coming from this burn further out when they meet with more air, and form a second cone.

The last thing we have to explain in the ordinary gas flame is the production of the yellow luminous patch, which, from the illuminating point of view, is the most important feature of all.

Now I need scarcely remind you that the general opinion is that this yellow patch in the flame is due to glowing carbon in a solid and very finely-divided state. The very familiar fact that a cold object introduced into the yellow part becomes coated with a black solid deposit, composed almost wholly of solid carbon, confirms this view. That this carbon or soot is solid in the flame is shown by the fact that it is deposited as a solid even when a highly-heated object is placed in the flame, and there are other proofs—some of them very pretty—which I cannot show for lack of time and of a means of magnifying.

This explanation is due to Davy, and constitutes his most celebrated discovery on the subject of flame. He describes it in the following words:

"When a wire gauze safe lamp is made to burn in a very explosive mixture of coal gas and air, the light is feeble and of a pale color, whereas the flame of a current of coal gas burnt in the atmosphere, as is well known by the phenomena of the gas lights, is extremely brilliant. . . . In reflecting on the circumstances of the two species of combustion, I was led to imagine that the cause of the superiority of the light of the stream of coal gas might be due to the decomposition of a part of the gas toward the interior of the flame where the air was in smallest quantity, and the deposition of solid charcoal which, first by its ignition, and afterward by its combustion, increased in a high degree the intensity of the light; and a few experiments soon convinced me that this was the true solution of the problem.

"I held a piece of wire gauze of about 900 apertures to the square inch over a stream of coal gas issuing from a small pipe, and inflamed the gas above the wire gauze which was almost in contact with the orifice of the pipe, when it burned with its usual bright light. On raising the wire gauze so as to cause the gas to be mixed with more air before it inflamed, the light became feebler, and at a certain distance the flame assumed the precise character of that of an explosive mixture burning within the lamp, but though the light was so feeble in this last case, the heat was greater than when the light was much more vivid, and a piece of wire of platinum held in this feeble blue flame became instantly white hot.

"On reversing the experiment by inflaming a stream of coal gas and passing a piece of wire gauze gradually from the summit of the flame to the orifice of the pipe, the result was still more instructive, for it was found that the apex of the flame intercepted by the wire gauze afforded no solid charcoal, but in passing it downward solid charcoal was given off in considerable quantities, and prevented from burning by the cooling agency of the wire gauze; and at the bottom of the flame, where the gas burnt blue in its immediate contact with the atmosphere, charcoal ceased to be deposited in visible quantities."

Only one attempt has been made to disturb the conclusion here drawn by Davy. In 1868 Prof. Edward Frankland, to whom we are indebted for many important discoveries respecting flame, came to the conclusion that the light-giving agency in flames was not solid carbon, but certain complex vaporous compounds of carbon and hydrogen. I regret very much that time will not admit of my detailing the evidence in favor of this view, or the counter evidence by means of which most chemists have been persuaded that Davy's explanation was, after all, the correct one. It is, however, right to remark that Prof. Frankland not only adheres to his own view, but promises to adduce further evidence in its favor.

Let us for the present, at any rate, stick to the opinion of the majority, and admit that the bright light of ordinary flames is due to incandescent particles of solid carbon. The next question is, How does this carbon become separated?

This question is dealt with by Davy, but in language of some ambiguity. He says, "I was led to imagine" . . . . that it "might be due to the decomposition of a part of the gas toward the interior of the flame where the air was in smallest quantity, and the deposition of solid charcoal which, first by its ignition and afterward by its combustion, increased in a high degree the intensity of the light."

Whatever these words may have been intended to mean, or whatever interpretation is the fair one, it is certain that Davy's explanation was soon presented as if it implied lack of air to be the chief cause of carbon separation. As there was a large quantity of hydrocarbon and only a small amount of oxygen in the central parts of flame, the hydrogen, it was said, being the more inflammable element, will seize upon this oxygen and leave the carbon uncombined. The fact that this version was given by Faraday lends some countenance to the belief that it was a fair representation of Davy's view.

Now this doctrine was really incompatible with facts known, though apparently not widely known, at the time. I have already referred to the fact that Dalton at the beginning of the century showed that when a hydrocarbon is exploded with a supply of oxygen insufficient to burn both the hydrogen and the carbon, it is the carbon, and not the hydrogen, which has the preference. If, therefore, we follow Davy in regarding flame as a tethered explosion, we cannot explain the separation of carbon as being due to the preferential combustion of the hydrogen. This fact was clearly pointed out by Kersten in 1861, but notwithstanding this, and other investigations tending to the same conclusion, the old view has somehow kept its ground down to the present day.

We must now turn to the alternative explanation, It is supplied by the words and, I think, by the intention of Davy. He says that the carbon separation might be due to the decomposition of the gas toward the interior of the flame. If this decomposition be not due to chemical action, it must be due to heat; and certain it is that hydrocarbons when strongly heated do decompose, and do deposit carbon. Here is a result of this action occurring on a large scale. This gas carbon, as it is called, is deposited in gas retorts owing to the action of intense heat on the hydrocarbons of the gas.

In another place Davy says: "I have shown in the paper referred to in the introduction, that the light of common flames depends almost entirely upon the deposition, ignition, and combustion of solid charcoal, but to produce this deposition from gaseous substances demands a high temperature."

This explanation of carbon separation in flames seems perfectly adequate and free from objection. There is, as we have seen, surrounding all ordinary hydrocarbon flames a shell of almost non-luminous combustion. The gas which passes upward within this shell must be highly heated, and in the absence of air will be decomposed so as to deposit solid carbon. This carbon is intensely heated, and glows, and as it reaches the air will burn to form carbon dioxide. The fact that the upper parts of flame are the most luminous in itself indicates that the more we roast the gas the more do we separate the carbon; and there are other proofs which I cannot stop to explain.

We have now got pretty well to the end of the explanation of the structure of ordinary luminous flames, and I will show you an experiment which epitomizes the explanations that have been given.

We turn once more to the cone-separating apparatus, and use as fuel a substance particularly rich in carbon. This substance, benzene, is a liquid; so I shall have to vaporize it by means of a current of air. When I apply a light to this current of air strongly impregnated with benzene, we get, as you see, a very bright flame. This flame exhibits the usual structure. This is one extreme. Now I will reduce the amount of benzene vapor very rapidly without altering the air, and we shall get the other extreme, that is, a scarcely luminous flame, consisting of one single cone. The whole of the combustion is now taking place in a single cone of flame. If I still further reduce the benzene, this flame enlarges slightly and becomes paler. There is now excess of air. A little less benzene still, and you see the flame rises from its perch and disappears; we have got past the limits within which combustion is possible. Let us next move in the other direction and gradually increase the supply of benzene to the single cone. It becomes smaller and brighter as we proceed up to a certain point. At length we have evidently got more benzene than there is air to burn, and now appears the second cone at the top of the tube. By sliding the tubes we can unite the flame and make a Bunsen flame. Separating the cones again, let us add still more benzene. The result is very remarkable. The two cones remain intact, but stretching between them are thin luminous streaks of glowing carbon. The excess of benzene is being decomposed by the heat, so that the carbon separates and glows. The more benzene I add, the broader do these streaks become, until eventually the inner cone ascends, the luminous streaks coalesce, and we have the ordinary luminous hydrocarbon flame.

I have now put before you the considerations and methods which will serve, I believe, for the elucidation of all problems of flame structure. I am not aware, at any rate, of any flame which does not accord with the general principles which I have explained to you.

There are many other flame problems besides that which relates to mere structure. Of these one of the most interesting concerns the coloration of flame. I will refer to it for a moment only to show how closely that question is connected with the points we have been discussing. I have here a gas flame to which I feed air until its yellow luminosity has disappeared. If I add to the air supply the fine spray of a dissolved copper salt, the flame assumes a green tint characteristic of the metal. This green tint seems to belong to the whole flame, but if we dissect it by the apparatus already so often used, we find that the green tint is developed only in the outer cone. It is due, in fact, to oxide of copper, which can only exist on the outside of the flame. Similar peculiarities are noticed with some other colored flames, and it is hoped that their study, which leads us into the domain of spectrum analysis, will yield some interesting information on points which are at present very obscure.

I have directed your attention this evening to terrestrial flames of small dimensions, but in conclusion I should like to remind you that at one time there were probably quite other flames upon this earth. The globe we inhabit is in the process of cooling and of oxidation; at one time we believe, in fact we know, that it was incandescent. If we take a chemical retrospect and imagine as we recede in time our present cool earth becoming hotter, we may follow out some interesting changes. We should soon reach a temperature too high for the persistence of liquid water; our oceans would be evaporated and surround the globe as an envelope of steam. In remoter times and at higher temperatures this steam could not exist even as steam, but

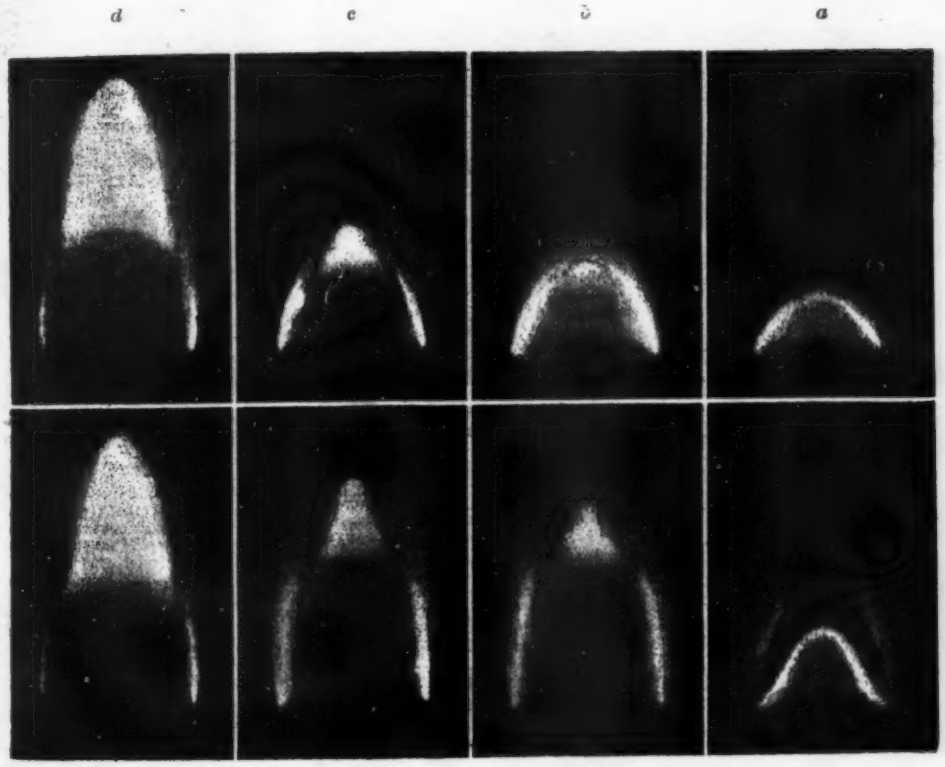
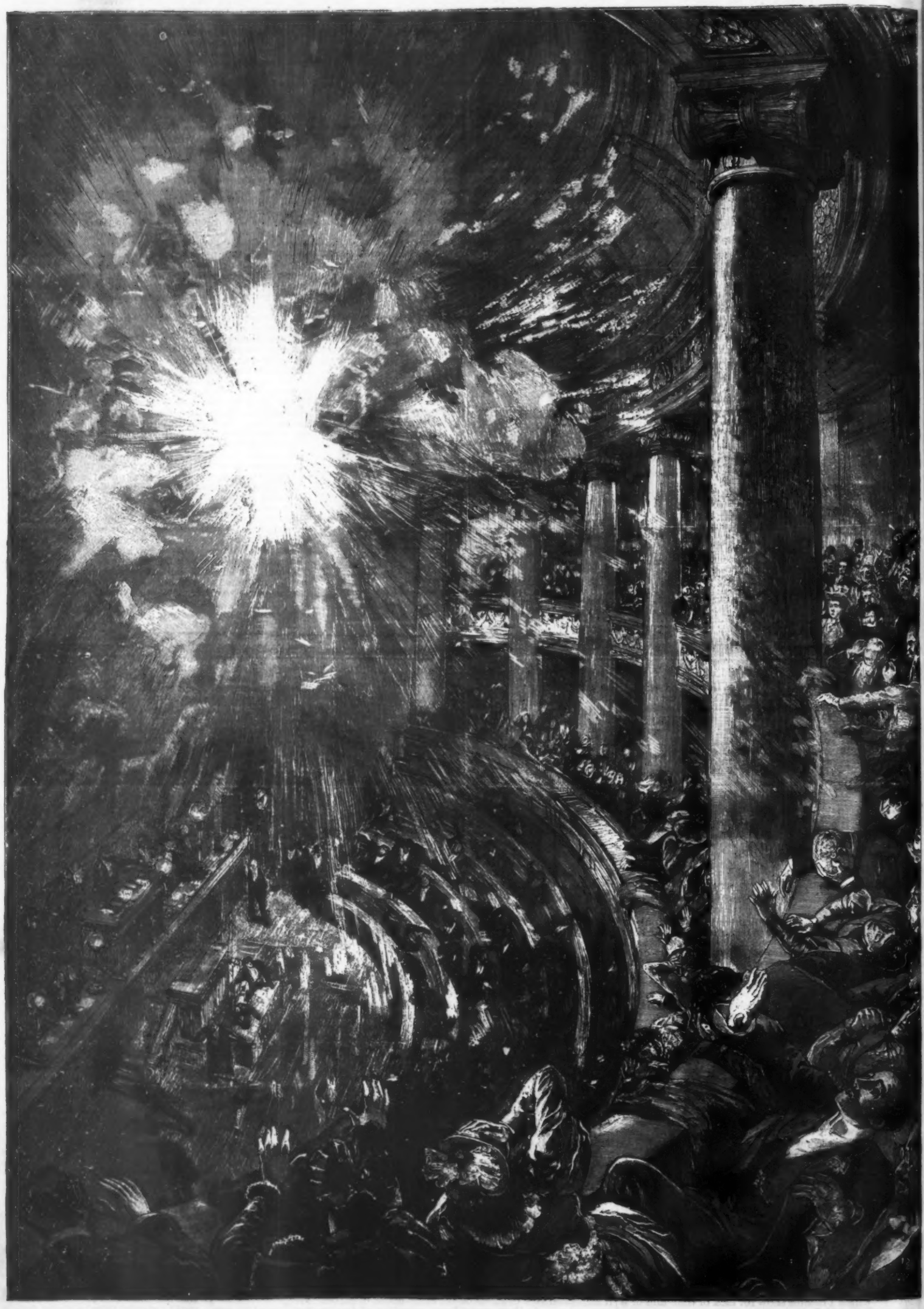


FIG. 3.—*a*, *b*, *c*, *d*, flames with successively increasing quantities of coal gas. *d*, *e*, *f*, *g*, flames with fixed supply of coal gas and successively increasing quantities of air.



THE EXPLOSION OF DYNAMITE IN THE CHAMBER OF DEPUTIES, PARIS, DECEMBER 9, 1893.—*From the Graphic, London.*

would be dissociated into hydrogen and oxygen. At that time, too, many of the elements now existing as oxides in the solid crust of the earth would be floating in a gaseous state in the vast atmosphere. Let us stop our retrospect at this point, and look toward the present with a cooling earth. At a certain point chemical combination must have begun in the fringe of the ancient atmosphere, and it must have been the scene of colossal chemical activities, the hydrogen and vaporous metals flashing into their oxides. On gravitating to hotter regions, these combinations may have been again undone, the elements sent again into circulation. How long such a period may have lasted we need scarcely stop to ask. If the retrospect is reasonable, it is enough. It is interesting to think how such an earth as we have pictured must have resembled the sun as we know it at the present day.

There was formerly a chemical theory of the sun, which ascribed both its heat and light to the act of chemical combination. That theory has long since been refuted and discarded, and with it ordinary laboratory chemistry banished from that luminary as altogether unsuited to its high temperature. There is cause, I think, to ask if this is quite warrantable. We know extremely little of chemistry at high temperatures, but if the sun could be shown to have its reasonable share of oxygen, we might well ask if its surface phenomena were not largely ascribable to ordinary chemical activities and of the nature of flames. It is certainly remarkable, when we consider the unity of plan in which heavenly bodies are seen more and more to move and have their being, that the sun should not exhibit the possession of its fair share of that element —oxygen—which has ruled the chemistry of the earth throughout all geological time and long precedent ages of its evolution. But this is ground which the terrestrial chemist must tread with care. He still has many unsolved problems lurking in the flame of a common candle, and flame, wherever we find it, is still a mystery.

"The power of fire or flame," says Carlyle, "which we designate by some trivial chemical name, thereby hiding from ourselves the essential character of wonder that dwells in it as in all things, was with the old northmen Loke, a most swift, subtile demon of the brood of the Jotuns. The savages of the Landrones Islands too (say some Spanish voyagers) thought fire, which they never had seen before, was a devil or god, that bit you sharply when you touched it, and that lived upon dry wood. From us, too," adds Carlyle, "no chemistry, if it had not stupidity to help it, would hide that flame is a wonder."

THE DYNAMITE EXPLOSION IN THE CHAMBER OF DEPUTIES, PARIS.

ANOTHER link in the chain of Anarchist outrages was forged December 9 last by the bomb explosion in the Paris Chamber of Deputies. Certainly, the Anarchists' scheme of vengeance is sufficiently comprehensive. In less than three months they have struck at a popular general and an aristocratic theater audience in Spain, at an Emperor and his Chancellor in Germany and now at the representatives of the sovereign people in France. But this last attempt has raised a storm of alarm and indignation which is likely to limit the Anarchist sphere of work very considerably. Hitherto, in France, at least, the police supervision has been distinctly lax. Otherwise such a well known bad character as Vaillant, the author of the crime, would not have been allowed to enter the Paris Chamber. According to the terms of the French constitution, the debates of the Lower House must be public, and a top gallery is reserved for the use of the general public without admission tickets. Very often, in winter, regular loafers come in for the sake of warmth and bring food with them, so that the entrance of a shabby man and a parcel would pass unnoticed. On December 9 the House was quietly discussing a contested election, when suddenly a red light shone in the air, a noise like pistol shots was heard and white smoke filled the building as a rain of nails fell around. A bomb had been thrown from the upper or public gallery. Happily, it had burst before reaching the floor, thus lessening the force of the explosion; but the results were bad enough. Deputies were stunned and bleeding, people in the galleries were groaning with pain and fright and for a few seconds panic prevailed. Then the House recovered itself, the injured were helped away and M. Dupuy, the President of the Chamber—who was himself slightly hurt—begged that the debate should continue. His coolness was infectious, and the work in hand was duly finished before the Premier said a few words promising firm government action and the sitting was closed. Outside the Chamber the officials had the good sense to shut the doors and keep prisoners all but a few of the public who escaped in the first confusion. The wounded were quickly attended to in the House itself, over fifty persons being injured, the majority slightly. The worst cases were those of the Abbe Lemire, hit on the back of the neck; an usher, M. Schillinger, the top of whose skull was blown off, and a spectator, who was obliged to undergo trepanning. All the sufferers are doing well. A cordon of troops had surrounded the building, and as the people were recognized as harmless they were let out, the police keeping back several suspicious individuals, including a man who called himself Marchal and was wounded in the face. After a short investigation this man confessed to the crime, and, with the customary bravado of his brethren, told how the bomb was thrown. The criminal threw it in such a manner as to appear that the bomb came from the next division of the gallery, but owing to a woman touching his arm his aim deviated, and the bomb struck a pillar and exploded prematurely.

This so-called Marchal proves to be a notorious Anarchist named Vaillant, who had borrowed a comrade's name to avoid detection. He has been in prison repeatedly since the age of sixteen and is well known to the police.

After the first shock of horror, Paris took the matter very coolly, reassured by the decision of the government to strike at the very root of the trouble. No time was lost, for M. Casimir-Perier appeared at the next sitting of the House with four strong repressive measures. These were a modification of the Press Bill of 1881, providing that incitement to robbery, murder, pillage and arson shall be punished by imprisonment; an alteration of the penal code relating to associations of malefactors; a modification of the law on explosives and the opening of an extra police credit. The first of these measures was particularly obnoxious to the Extreme Radicals as limiting the liberty of the press. But the House was so thoroughly roused that all the opposition of M. Goblet and his friends went for naught, and the government carried the day by 413 votes to 63. This enables the government to put down certain firebrand journals, which stir up the lowest class of the population to discontent and revolution. Stringent regulations for admittance to the Chamber have also been made, and no precaution is being omitted at the various public buildings. So far the outrage has decidedly turned the scale in favor of the present Ministry, for the Socialists, who were so strong a power in the new House, dare not raise their heads lest they should be confounded with the Anarchist party. There is a general feeling in France that international action should now be taken against the Anarchists, and most other countries share the opinion. No nation, however, cares to take the initiative, and her neighbors warmly urge France to lead the way. The utmost sympathy has been shown to France on all sides, nearly every parliament sending a message of congratulation to the Chamber. Russia is especially sympathetic, as she is just hearing of another conspiracy to assassinate the Czar.

When Vaillant was subjected to the examination in the hospital where he had been sent for the dressing of his wounds, he readily furnished a detailed description of the bomb. "It was," he explained, "a small iron saucepan which I bought at the bazar of the Hotel de Ville a few days ago. It was filled with nails, and among them was a tube compressed in the middle. In this tube there were two substances—picric acid and prussiate of soda, these being separated at the point where the tube was compressed by a small ball of cotton saturated with sulphuric acid. The sulphuric acid would, in a given time, eat away the cotton, and the other substances would then unite and produce an explosion."—*The Graphic, London.*

ELECTION RIOT IN GREECE—THE FIRE DEPARTMENT DISPERSES THE MOB.

A NEW USE FOR STEAM FIRE ENGINES.

THE recent elections in Greece were attended with grave disorders in several places, amounting in some instances to riots and personal violence. In the city of Athens party spirit ran so high that the governor deemed it necessary to make a rule there should be no gatherings in the public streets after nine o'clock at night. On one occasion a large public meeting was held in one of the principal squares, the orator of the occasion being the editor of one of the prominent newspapers. The proceedings were opened at 8.30 in the evening, and when the hour of 9 was sounded by the great clock in the Plaza, the editor had not finished his speech and declined to stop, as the governor required. This refusal brought on the prospect of a riot; whereupon the governor ordered out the steam fire engines in the vicinity, and the firemen drenched the talkative orator, suppressed his eloquence in the most effective manner and wet down the crowd, which dispersed, the people running to their homes to escape the unexpected deluge.

Our engraving is from *La Ilustracion Española.*

THE DEADLY AND MINOR POISONS OF TOADSTOOLS.*

By CHARLES MCILVAINE, M.D.

I USE the word toadstool as covering visible fungi and as distinguishing certain forms of fungoid growth from the microscopic. While many of the miscroscopic fungi number their human victims by the thousands, and are further reaching than co-conspirators of the visible sorts, their efforts are better understood by the medical profession than those belonging to the higher orders of which I shall exclusively write.

To Mr. Julius A. Palmer, of Boston, is due the segregation of the amanita—the aristocrats of the fungoid world—as the only mortal toadstool foe of man. To Dr. J. E. Shadle, of Shenandoah, Pa., must be given credit for describing the actual contact in the human system of atropine with the amanita poison.

The writer was fortunately enabled by these cases of Dr. Shadle to name the toadstools putting in their deadly work, and for the first time positively naming their foil face to face with them to the medical profession (see *Medical and Surgical Reporter*, "Amanitine and its Antidote," McIlvaine, December 12 and 19, 1885).

While atropine had been designated by such a writer as Dr. Gautier, Paris,* as a probable, certainly a theoretic, antidote for toadstool poisoning, it had never before been called upon to sustain its prognosticated reputation. Here is the best place to say that poisoning by amanitine must be met heroically by the subcutaneous injection of atropine, beginning with $\frac{1}{75}$ grain, and continuing until $\frac{1}{50}$ grain is administered; more, if necessary to save life.

It is unfortunate that the authorized dispensatories and pharmacopœias have settled upon muscarine as the name for this powerful alkaloid. The *Agaricus muscarius* is a member of the family of amanita. Its alkaloid is the base of the well known fly poison. Bulbosine, muscarine, are but family derivatives. All possess the qualities, and should bear the family name—amanita, amanitine.

Among peoples but little attention would be drawn to the amanita family, did it not so closely resemble the members of the common mushroom clique. To those familiar with both families there is not even a cousinly resemblance; but to those who believe themselves positive in their knowledge of "the only mushrooms fit to eat" there is a dangerous nearness.

In this paradoxical resemblance lies the prominence given to the amanita family, because of its seductive beauty and the fatal mistakes made in eating of its members.

All of the amanita have distinguishing marks. They wear royal robes of certain cut. They are all umbrella shaped. They all spring from a volva. Fragments of this ruptured sheath are frequently found upon the upper surface of the spread cap. About the base of the stem—generally bulbous—stays the principal part of the envelope from which they have burst. Up the stem, near the top and just under the white gills, is a ring surrounding it. Sometimes this hangs as a plaited skirt about the stem. Sometimes it is merely indicated by a yellow stain.

All of the amanita, being white spored, have white gills. The common mushroom, being purple spored, has pinkish gills in youth, which increase in depth of color as the spores ripen to a heavy purplish black. The amanita are choice in their habitat. They live in wooded depths or on the margin of timber lands. I have never found them in open fields and meadows. On the other hand, the common mushroom is never found in woods. It lives in the open. If these distinctions of growth and habitat could be impressed upon the public, there would be no more cases of amanitine poisoning.

The physician called upon to treat a case of toadstool poisoning, need not wait to query after the variety eaten; he need not wish to see a sample. His first endeavor should be to ascertain the exact *time* elapsing between the eating of the toadstool and the first feeling of discomfort. If this time is within four or five hours, one of the minor poisons is at work, and rapid relief will be given by the administration of an emetic, followed by one or two moderate doses of sweet oil and whisky in equal parts. Vinegar is effective as a substitute for oil. If from eight to twelve hours have elapsed, the physician may rest assured that amanitine is present, and should administer $\frac{1}{10}$ grain of atropine at once.

No stomachic troubles follow immediately the eating

* Abstract from the *Therapeutic Gazette.*

* "Les Champignons," Paris, 1884.

of the poisonous amanita. Digestion occurs without complaint.

It is possible that indigestible or mildly poisonous toadstools may have been partaken along with the amanita. In this case the time and symptoms would indicate the fact, and they should be eliminated from the system by the means mentioned. The patient should then be watched for the appearance of changes due to the more virulent poison.

One of the first symptoms is a peculiar ashy pallor of the complexion.

In relation to the latter, Mr. Palmer writes:

"The absorption of the poison from the amanita may take place not only by ingestion, but by contact with the skin, as through the hollow palm of the hand or arm; by the lungs, as I have proven by personal experiments made upon myself. In such a case the patient has all of the symptoms of having eaten of the mushrooms, *even to a peculiar leaden or ash-colored complexion.*"

Many of the amanita are not only nutritious, but delicious. Of the nearly forty varieties, not over eight are known to be deadly.

In testing, by carefully eating of over four hundred varieties of toadstools, for their edible and non-edible qualities, by smelling, by absorption of the juice while dissecting, I have frequently felt and seen on my own face symptoms of amanitine poisoning. My experiments upon dogs show that injections of minute quantities of an infusion in water or alcohol of any one of the poisonous amanita is fatal in from twelve to twenty hours, but that the fatal effects may be arrested at any but the final stage by varied doses of atropine. Similar results will obtain by the use of amanitine as an antidote for atropine. The difficulty I have encountered is in the separation of the alkaloid and obtaining solutions of known strength.

It should be borne in mind that the exhalations of those poisoned by amanitine are highly poisonous, and the urine as deadly up to the tenth or twelfth dilution, by passage through the human system, as the original poison itself.

Dr. Edward Jacob Forster, Boston, Mass., in an excellent monograph, entitled "Mushrooms and Mushroom Poisoning," read before the annual meeting of the Massachusetts Medical Society, June 11, 1890, says, "The treatment by atropine is based upon a perfect antagonism which exists between this drug and the poison of the amanitas, which has been separated by Professor Schmiedelberg, and named muscarine. The poison has been separated by others and variously named, according to the variety from which it was obtained. The merest trace of this alkaloid will arrest the pulsation of a frog's heart, and even after four hours Lauder Brunton states he has caused it to pulsate again by a minute quantity of atropine being brought in contact with the organ. This and other experiments showing the antagonism between these two poisons have been repeated by Professor H. P. Bowditch at the Harvard Medical School. It acts as well upon mammals as upon frogs."

[We understand Dr. McIlvaine has lately written a book, "Our Friends and Foes Among the Toadstools," which will soon appear.—ED. S. A.]

[FROM KNOWLEDGE.]

CURIOUS COCOONS.

By E. A. BUTLER.

THOSE insects which, just before assuming their final form, pass into a limbless, inactive condition, or, in other words, become a chrysalis and undergo a complete metamorphosis, evidently need some special protection during this period of rest, when they are unable to look after their own interests. And the need is intensified by the fact that the period of pupahood often lasts throughout the winter, so that the insect spends a larger proportion of its life in this helpless and passive state than in a condition of activity. The means adopted to meet the need are varied, but the majority of cases may be grouped under two heads: either the insect buries itself in the ground or, remaining above ground, envelops itself in a silken covering or cocoon. While the former method, from the nature of the case, presents few peculiarities and calls for little remark the latter is full of interest in consequence of the variety of form and the remarkable adaptations and contrivances which the cocoons exhibit; we therefore propose briefly to discuss the most interesting of these specimens of insect architecture which are to be met with in the woods, fields and hedges of our own country. We naturally look to the Lepidoptera for our chief, though not for our only, examples; the most notably cocoon constructing section of this order is the group called Bombyces, including the moths known in popular phraseology as "tigers," "ermines," "eggers" and "emperors."

But before referring to specific instances in detail, a few words are necessary as to the organ by which the material used in these constructions is produced. There is a pair of glands which are found only in the larva, and disappear in the adult insect, and in these the silk is secreted as a gummy substance. They are bent and coiled tubes, lying at the sides of the body, and they sometimes extend for a considerable distance from the head toward the tail. Their structure is similar to that of salivary glands, but they do not communicate with the mouth, and consequently the silk does not, as at first sight it appears to do, issue from the mouth. The ducts from the glands unite into a common canal, which opens upon a minute papilla a little below the mouth, and from this the secretion exudes. Though glutinous at first, it has the property of drying and hardening as soon as exposed to the air, thus losing its stickiness. In this, as well as in other respects, it differs from the silk of spiders, which is secreted by glands at the opposite end of the body, and which, as serving the purpose of a snare, remains more or less sticky after exposure.

The cocoons of different species vary in color from white, through shades of yellow, brown and gray, to almost black; but this is probably not entirely due to differences in the natural tint of the silk, but to processes it undergoes after having been spun, or to the admixture of foreign matter. The larva always forms its cocoon round itself, so that it is usually an entirely closed covering, with no indication of a way of entrance or exit. As it is most commonly constructed among twigs, dead leaves, etc., or in crevices and corners and under ledges, a few threads are first run promiscuously among surrounding objects to serve as a sort of scaffolding or mooring, and then a much more compact structure is fashioned in the center of these, so as closely to envelop the body of the spinner.

It is difficult to say what have been the influences that have determined the shape of the cocoon in each species; certainly neither the shape of the caterpillar nor that of the chrysalis is the factor of prime influence, since we find that caterpillars of similar shape make very different cocoons, while there are caterpillars of very dissimilar appearance which make cocoons more or less alike; and there seems no particular reason why a shape that suits one would not equally well suit another. Moreover, it sometimes happens, as with the emperor moth to be presently described, that the small end of the chrysalis lies in the big end of the cocoon, so that no attempt is made to secure what tailors would call a "good fit." The protection afforded by the inclosure of the pupa in a cocoon is not necessarily entirely in the direction of the disappointment of insectivorous enemies—in fact, as to the extent to which this sort of protection may be necessary there is great lack of definite information, and whatever opinion may be formed will be more or less conjectural; we are not in a position to say exactly, from actual observation or experiment, what insectivorous animals would be glad to feed upon these pupæ, but are balked in their desire by the presence of the cocoon. Besides this somewhat hypothetical advantage, however, there are the obvious benefits of the degree of fixity the cocoon gives to a body which, if lying free and loose on the ground, would be at the mercy of any disturbance in its surroundings and of the shelter afforded by inclosure in a non-conducting and probably damp proof medium amid changing climatic conditions, especially when its use is required during the winter season. But there is abundant scope for inquiry in all these directions, and if any of our readers feel inclined to investigate the subject for themselves, they will doubtless be rewarded with discoveries.

Among the numerous cocoons formed by British insects none is more remarkable than that of the emperor moth (*Saturnia carpini*) (Fig. 1). As a rule, cocoons are more or less oval in outline and of similar shape at each end, but in the present instance we have a pear-shaped or flask-shaped body, rounded and swollen at one end and with a large circular opening at the other. A little distance below the opening a set of stout threads, almost like bristles, pass from the inner wall of the cocoon all round in an upward direction toward the center of the opening, where they meet, thus closing the cocoon by a hollow, conical, brush-like partition, which effectually bars entrance from without, but admits of easy egress from within by merely pushing the threads on one side. Thus, by this very simple but exquisite contrivance, no obstacle is placed in the way of the exit of the moth when matured, although the precious contents of the chamber are during the long continuance of pupahood securely shut off from any would-be robber in the outer world.

FIG. 1.—Cocoon of Emperor Moth, part of outer wall being removed at the top to show conical barrier of fibers.

The color of these cocoons is variable; usually they are some shade of deep brown, but sometimes they become of a pale creamy white. It has been supposed by some naturalists that this difference is intentional, and that its object is to enable the cocoon to harmonize more completely with its surroundings, and so more effectually to elude notice. Many careful experiments have been made to determine this point, since if established it would be a more remarkable physiological fact than the change of color in the surface layers of a caterpillar's skin, under the influence of external colors, to which we alluded some time ago. For we are not here dealing with a case of concealment brought about by the attachment of foreign objects of suitable color selected from the surroundings, a case which would imply no more than a certain degree of intelligence and ingenuity on the part of the fabricator of the cocoon; nor is it an instance of the color of the caterpillar itself being so modified as to correspond more closely to its surroundings; but it would be an instance of a living being retaining its own color unchanged, but possessing the power of modifying the color of its deep-seated secretions at will, or at any rate in response to external optical stimulus merely, notwithstanding that usually the act of secretion is one of the most unconscious and involuntary which take place in the life of an organism. The experiments did not lend much support to the hypothesis of protective coloration, but pointed strongly toward a different reason for the presence or absence of the dark brown color.

By first inclosing single caterpillars which were about to spin in pockets made of various materials, some dark, others light, and, secondly, inclosing families of caterpillars in white and black muslin bags, abundantly supplied within with crumpled pieces of white and brown paper respectively, so as to make the surroundings as uniformly light or dark as possible, Mr. W. Bateson has shown that the color of the cocoon is independent of that of the material on which it is built. for dark cocoons were attached both to dark and light substances indifferently, and *vice versa*. But it was observed that the more natural were the surroundings of the caterpillar, and the less it was interfered with at the close of its larval career, the greater was the tendency to form a dark cocoon, the light ones being made specially by those which had been removed from their food plant. Continued association with the food plant up to the time of transformation thus seemed necessary for the construction of cocoons of full color. It was further observed that the caterpillars had the power of ejecting from the mouth a green liquid, which, apparently, by a process of oxidation, became brown on exposure to the air; and that, in all probability, a similar fluid was voided from the hinder extremity of the alimentary canal. There were many indications, which we have not space here to detail, that it was this fluid, derived from the partially digested food and ejected from the alimentary canal, which stained the cocoons and gave them their brown color, and that when light cocoons were made, the caterpillars had probably already voided this fluid before their isolation, and therefore possessed no further store to stain the cocoon as soon as it should be made; or, by being removed too early from their food, failed to make the fluid, and were therefore unable to give the cocoon the usual layer of coloring. Thus the color of the cocoon would seem to be dependent, not upon the predominant tint of the surroundings, but upon the condition of the caterpillar at the time it is made.

Of course it still remains an open question why this liquid should be poured out upon the cocoon at all, and in what way it may conduce to the well-being of the insect that its abode during its time of quiescence should be thus varnished. The coloring substance, though soluble in water at first, becomes incapable of being washed out when once the cocoon is stained, thus proving itself a fast color. It is an obvious suggestion that this dyeing of the cocoon may have something to do with rendering it impervious to the rains of winter; but it is hardly safe to hazard such a conjecture, since other equally plausible suppositions might no doubt be made, which yet experiment might show to be untenable; it is better, therefore, to wait for the results of further experiments before coming to any definite conclusion.

It should be remarked that there seems no particular need of further protection to the chrysalis than that which it already possesses in being inclosed within the very tough skin of the cocoon. Any insectivorous animals which might otherwise feel disposed to prey upon it would apparently be sufficiently kept at bay by this very unmanageable material, so that special efforts for the concealment of the besieged after the acquisition of so excellent a breastwork would seem to be only wasted energy.

The egger moths are so called because of the very compact, egg-like cocoons they make. The two species best known in this country are the oak egger, a fine large yellowish brown moth, which appears in summer time, and the small egger, a much smaller species of a reddish brown color tinged with ashy gray, which makes its *debut* in midwinter. The cocoons of both of these are very similar—parallel sided, and equally rounded at each end (Fig. 2). The silk is close and

FIG. 2.—Cocoon of Oak Egger Moth.

compact, and forms a parchment-like shell, thin but hard, and extremely smooth within; in each case it is an exceedingly close-fitting cell, which is not more than half the length of the caterpillar that makes it; hence it follows that, as the artificer is accommodated within during the whole of the time of construction, it finds itself very cramped for room as it turns about and carries its thread from side to side. The small egger, in some unaccountable way, always leaves a minute perforation in one side of its cocoon, an arrangement which its larger relative does not imitate. From this hard and compact shell the moth makes its escape by pushing off from one end an irregular piece, which looks as if it had been bitten round. When we remember, however, that the moth is entirely destitute of biting jaws of any kind, the real method of escape is seen to be a great puzzle, for the separation of this portion of the cocoon clearly implies the severance round its edges of the crossing and recrossing threads of which the cocoon is composed, and it is difficult to understand how that should be done without a biting or cutting instrument. Careful watching of the emerging moth is here of little use, for the cocoon is opaque, and the attack is made from within, and when we catch the first glimpse of the head of the newly-fledged insect issuing from the cocoon the deed is already done, and the escaping prisoner has kept its secret as effectually as Messrs. Maskelyne and Cooke in their escape from within their closely corded box.

The problem has, however, recently been somewhat satisfactorily attacked in the case of a different insect, and one imprisoned, it might be imagined, more entirely beyond hope of escape than either of the above. The moth in question is the puss moth (*Dicranura vinula*), of whose extraordinary caterpillar we gave our readers a description some time ago (*Knowledge*, February, 1893).

This creature selects a crevice in the bark of a tree, and excavating it into an oval hollow, roofs itself over on a level with the surrounding bark, with a layer of mixed silk and chewed bark, which closely imitates the color and roughness of the true bark, so that often nothing less than the closest and most minute scrutiny avails for the discovery of the cocoon. This roof of mingled silk and sawdust does not reveal distinct threads, as has been the case with the other cocoons, but seems to be composed of one continuous mass; it becomes so hard and unyielding that the blade of a knife, unless very firmly pressed, slides off and makes no impression on it. This intensely hard roof completely covers in the dumpy brown chrysalis into which the brilliant caterpillar changes, and from this at the end of the following spring issues the large fluffy soft-

bodied moth, with its whitish wings prettily penciled with gray streaks, in a manner which recalls the markings of a tabby cat. In this case, as before, a portion of the hard shell is burst off just above the anterior end of the chrysalis, making a hole just large enough for the moth to squeeze itself out. Thus the problem is repeated, and with an added intensity. How can a soft-bodied creature, with no jaws or claws, work its way through a partition almost as hard as if it had been made of metal?

For the solution of the problem the analytical chemist had to be appealed to, for the moth, not having sufficiently strong mechanical means to free itself from its prison, invokes the aid of chemistry. Mr. Oswald Latter removed some pupæ from their cocoons shortly before their emergence, and wrapped each up in a piece of the thin blotting paper used by chemists for filtering solutions. Each, therefore, on becoming a moth, had to pierce the paper instead of its cocoon. As this took place it was found that the paper was wetted at the spot of emergence, a stain being left behind when it dried. By using a number of these stained papers, enough of the material which composed the stains was procured to enable an analysis to be made. It was then found that the liquid, which was evidently poured out by the moth at the time of its emergence, was none other than that very well-known substance, caustic potash, renowned and widely used for its solvent powers. This was a very interesting discovery, for it had not previously been known that any animal secreted a caustic alkali; moreover, it was doubly interesting from the fact, to which we have previously referred, that the caterpillar of the same moth secretes a liquid of a chemically opposite character, viz., formic acid. The next step was to try whether the material of the cocoons was soluble in caustic potash. A few drops were placed on the inside of some cocoons, and in three minutes they were reduced to a pulp. Here, then, stood revealed the means by which the creature was able to effect a breach in its strong prison walls; it actually dissolved its way out by means of a caustic alkali.

But the explanation was not yet quite complete, for if the alkali were the only means of egress used, it seemed likely that there would result a general softening of a part of the wall of the cocoon, and a bursting out through that, rather than, as was really the case, the neat separation of a portion of the wall, the severed piece remaining as hard as the rest. The moth was found to make its exit wearing a sort of cap, consisting of the front part of the chrysalis shell, which fitted on to its head by means of little projections and sockets and served as a shield protecting the underlying parts from damage during the passage out. Close examination revealed just beneath this shield a couple of hard sharp points projecting from above the moth's mouth, and usually concealed by the fluffy down around. These are the instruments by which the section is made, though they would be quite powerless if the silk were not first moistened and softened by the secretion. Thus the moth is most wonderfully armed for burrowing its way out; with a shield on its head, two diggers beneath, and a supply of alkali to overcome the resistance of the wall it has to penetrate.

When cocoons are attached to grass stems, they naturally tend to become shuttle-shaped; the stem runs up one side, and the ends of the cocoon taper away till they are reduced to the thickness of their support. Two very good instances of this are to be seen in the "drinker" moth and the family of burnet moths. The caterpillar of the "drinker" (*Odonestis potatoria*) is a hairy creature with two extra long and close tufts of black hairs like horns, one at each end, and also with a number of short snow white and deep yellow or orange tufts along the sides. It feeds on grasses, and has the habit, when disturbed, of dropping to the ground and rolling into a very compact ring. The moth is colored something like the oak egger, but it is not so large; nevertheless, the cocoon (Fig. 3) is a good deal larger. It is of a pale yellowish color, leathery and flexible, and thus quite unlike those we have just been considering. It has a slightly irregular and crumpled appearance outside, but inside is smoother, although the individual silken threads can be much more distinctly traced here than outside, where the texture looks more irregular and matted. Some of the caterpillar's hairs are worked into the structure outside.

FIG. 3.—Cocoon of Drinker Moth, on grass stem.

The burnet moths are extremely brilliant insects, which frequent grassy hillsides and meadows, and delight to fly in the brightest sunshine. There are several kinds, but they are all narrow winged moths, with long stout bodies; the forewings are of a brilliant metallic greenish black, adorned with crimson spots, and the hind wings are rich crimson with a black border. The commonest species (*Zygæna filipendulæ*) has *six* crimson spots on the forewings, and is an abundant and well known insect in suitable localities. The cocoons of these creatures are of a shining golden color, thin and papery in consistence, but nevertheless harder and more unyielding than that of the "drinker," as well as much smaller. They are usually attached to grass stems, and three or four are sometimes placed on the same stem (Fig. 4), either one above the other or clustering round at the same level, and, therefore, more or less overlapping one another. Their bright color and elevated position makes them very conspicuous objects. Occasionally the cocoons are constructed in other places, such as on fern fronds, thistle stems, or even stones, but the grass stem is the general rule—a rather curious association, since grass is not, as it is with the "drinker," the food plant.

FIG. 4.—Four cocoons of Burnet Moth, on grass stem, the empty chrysalis cases projecting.

There is no difficulty in telling whether the insect is within or not, for when it escapes it leaves the front half of the empty chrysalis case sticking out of a hole in the cocoon, and the contrast between the black shell and the golden vase which supports it is very striking. This position is assumed by the chrysalis before the emergence of the moth, whence it is evident that, though limbless, it has the power of climbing; the means of doing this consist of rows of minute hooks on the segments of the abdomen, just as with the leaf-rollers we described on a former occasion. In this habit the burnets are quite unlike the other insects we have referred to, which, as they have no hooks and cannot climb, all leave their empty shells wholly inside the cocoons. Another difference is that the cocoon is simply burst open at the end, and no part of it is actually separated from the rest. But here again we find a resemblance to the "drinker," which does the same; and since in this case the chrysalis skin does not project, and the cocoon is scarcely damaged by the escaping moth, it is not an easy matter except by the touch, to decide whether the cocoon is empty or full. Neither "drinker" nor burnets require the accommodation of the cocoon for more than a few weeks at the outside, and when once they are broken open and deserted, the weather soon makes them more and more dilapidated, and they are not long in going to ruin.

When once a moth has escaped from its cocoon there is generally no further use for the deserted shelter, and it is left to take its chance of wind and weather. But in one or two instances, at least, this rule does not hold good, and the vacated cocoon still serves a useful purpose in the economy of the insect. The vaporer moth (*Orgyia antiqua*), whose curiously tufted and tussocked caterpillar we alluded to on a former occasion, employs its old cocoon as a receptacle, or rather support, for its eggs. In every part of its economy this insect is an odd creature. It is one of those few Lepidoptera the females of which are practically wingless. The male insect is a lover of bright sunshine, and flies in search of its apterous and stay-at-home mate during the hottest parts of summer days. As it is an exceedingly common insect, and the caterpillar feeds upon a variety of shrubs which are among those cultivated by man, it makes itself quite at home in the gardens and squares of our large towns, and may often be observed gayly fluttering along the streets in the neighborhood of its home. It is a modest little broad-winged, russet-colored insect, with a crescent-shaped spot of white toward the outer and lower corner of each forewing and with beautiful comb-like antennæ. Its partner does not rely upon beauty as a recommendation, for she is one of the plainest-looking creatures imaginable, and it requires a stretch of charity to refrain from calling her positively ugly. She possesses the merest rudiments of wings, though, as she never uses them, she might as well have none at all. Her figure exhibits an excess of obesity which, to the human eye at least, is sufficiently repulsive, but apparently it has its attractions for her own kind, for the males will come long distances for the honor of becoming the possessors of her unwieldy frame. Her body is clothed with a thick covering of pale, grayish hairs. She never leaves the cocoon which was the home of her pupahood, but waits upon it till the arrival of her accepted swain, after which she lays her eggs, scattering them over the surface of the cocoon, the greater part of which they are generally numerous enough to cover. This done, she dies.

The cocoon is loosely constructed; the silk is fine and glossy, but as many of the caterpillar's hairs are intermingled with it, the texture appears coarse and irregular, and the black, brush-like hairs that belonged to the tufts at the sides of the neck and at the tail are sometimes conspicuous objects among the otherwise pale yellowish mass (Fig. 5). The cocoon is not a complete one, like most of those described in our last paper, but should rather be described as simply a web forming a roof arching over the chrysalis, the surface of a tree trunk or wall constituting the base of support and occupying the whole of the other side. The chrysalis is of a deep brown color, and, strange to say, is ornamented with tufts of hairs on its different segments, a feature which is, however, characteristic of the family. The scattering of the eggs over the web may, perhaps, in some way be connected with the unusual circumstance that the eggs do not all hatch at the same time, but the young caterpillars continue to issue from them during a period of ten weeks, so that eggs, caterpillars, pupæ and perfect insects may all be met with at the same time during the summer. Another species, called the scarce vaporer moth (*Orgyia gonostigma*), a much less common insect, has similar habits.

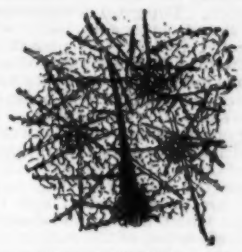


FIG. 5.—Part of cocoon of Vaporer Moth, showing one of the black brush-like hairs. Magnified six diameters.

It may be taken for granted that hairy caterpillars will, as a rule, intermix their hairs with their silk, thereby effecting a considerable saving of material; but this is not very different from saying that cocoons may generally be expected to contain hairs, for it is chiefly, though not exclusively, hairy caterpillars that make cocoons, and the longer and more numerous the hairs with which the caterpillar is clothed, the larger will be the proportion they will bear to the silk in the construction of the cocoon. This is very manifest in the slight web formed by the garden tiger moth (*Arctia Caja*), whose caterpillar, popularly known as the "woolly bear," is the hairiest of a hairy family. The web is thin, and the dark hairs are extremely conspicuous. This is also true of the rest of the "tigers," belonging to the same genus, and of the "ermines," belonging to the genus *Spilosoma*, and the color of the cocoon is, therefore, obviously determined largely by that of the caterpillar's hairs. Now, it is clear that if an attempt were made to utilize the silk of such cocoons, the numerous hairs scattered among and clinging to the threads would become a serious inconvenience in the unwinding of the silk, even should the threads of the latter be sufficiently continuous to make such a procedure possible. It is fortunate, therefore, that the silk worm of commerce is not a hairy insect, for if it were it woul assuredly mingled its hairs with its silk and thus render its cocoon useless for manufacturing purposes. The fact that it is hairy when first hatched, though it loses its hairs almost entirely at the first moult, seems to point either to an original adult hairiness when in a wild condition, or at least to its descent from hairy ancestors. As the present excellence of the silk is, no doubt, due to long domestication and careful selection, it is quite possible that a reversion to hairiness of body in the adult condition would be accompanied by a deterioration in the quality of the silk itself, quite apart from what would result from the admixture of hairs.

Among other curious lepidopterous cocoons may be mentioned that of the lackey moth (*Clisiocampa neustria*), yellowish white, and supplied when first formed with abundance of pale yellow powder like flowers of sulphur; this is at first scattered through the silk, but gradually collects in the lowest corner and soon after falls out altogether through the meshes. The two beautiful moths called "green silver lines" (*Halias*), whose forewings are of a delicate pale green with two or three white or yellowish lines drawn across them, make cocoons like an inverted boat. Passing to exotic insects, we find some very curious cocoons among the silk-producing Bombyces. One of the most extraordinary is that of the tusser silk moth. This is a large moth of a pale fawn color, with transparent circular windows in the center of its wings; it is a good deal reared in India for the sake of the silk obtained from its cocoon. The cocoon is oval, hard and compact, without loose outlying threads, seeing that it is not anchored as usual, but is suspended at the end of a stout stalk, the further end of which forms a circular loop tightly fastened round some twig of the food plant, so that the cocoon hangs from the bough like a kind of fruit (Fig. 6).

FIG. 6.—Cocoon of Tusser Silk Moth.

Our next illustrations will be taken from the order Coleoptera, or beetles. Many of these insects feed upon plants, and among these vegetarian groups are several species that construct cocoons. Two of the

most interesting instances may be mentioned, both taken from the beetles called weevils. A weevil may be easily recognized by the peculiar structure of its face; this is prolonged into a longer or shorter beak or snout, sometimes reminding one of an elephant's trunk, and carrying the mouth organs at the tip. *Hypera variabilis* is the name given to a brownish species which feeds upon various leguminous plants, and, while generally common, is sometimes found in absolute profusion. The grub of this creature, a short caterpillar-like being, covers its body with a sticky substance secreted by a gland placed at the tail. When it has eaten its destined amount of lucerne or other leguminous food, and reached its full size, it retires to the underside of a leaf, and begins to construct there, with this same sticky substance, a kind of oval cage consisting of a thin and open network of threads. Within this the little creature enters upon its pupal experience, remaining, of course, still visible from the outside through the meshes of the network. Few natural objects are more graceful and delicate than these little cages, which may often be seen attached to leaves. The construction of the cage is rather a slow business, occupying, although it is not a large structure and the network is but one layer thick, about twenty-four hours in completion. So delicate a structure would, no doubt, stand but little wear and tear, and would be a most imperfect shelter against climatic changes; but fortunately its durability is not greatly put to the test, for the perfect beetle is rapidly developed within, and issues after only a few days of captivity. The genus *Hypera* is a large one, containing sixteen British species, the habits of all of which are similar to those detailed above.

The other instance of beetle cocoons is that of the genus *Cionus*. Here we have half a dozen species of extremely pretty weevils, with large globular bodies, variously colored, and always adorned with raised velvety patches, some of which are rectangular streaks and others circular disks. These beetles are specially attached to one order of plants, the *Scrophulariacea*, and particularly to those members of it called figworts (*Scrophularia*). The figworts grow in damp places in tall clusters; they may be known by their disagreeable odor, their succulent stems carrying opposite pairs of smooth, broad, rounded leaves with notched edges, and their bunches of small, deep red, cup-shaped flowers at the top. The flowers do not all open at the same time, so that often there may be seen on the same cluster buds, flowers, and seed vessels. Sometimes the leaves of these plants are seen to be riddled with holes, as though some one had been making them a target for the discharge of small shot; the leaves are then more or less dry and brown. This damage is wrought by the larvæ of weevils belonging to the genus *Cionus*, and a little close inspection will usually reveal the beetles crouching down on the leaves; or failing this, if the eyes be carried to the bunch of flowers, buds, and seed vessels at the top of the stem, a still more careful scrutiny will probably detect a number of oval olive-brown bodies among the rounded buds and seed vessels, and very closely resembling them in appearance (Fig. 7). These are

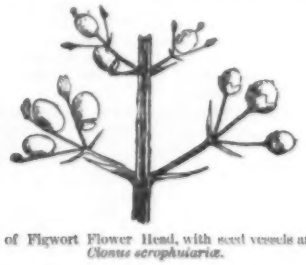


FIG. 7.—Part of Figwort Flower Head, with seed vessels and cocoons of *Cionus scrophulariæ*.

the cocoons of the beetles, and though perfectly exposed, they are yet beautifully concealed by their resemblance to the fruitage of the plant. In many respects the economy of these insects is like that of the genus *Hypera*; there is the same sticky secretion on the larvæ, furnished by a gland at the tail, and as before it is worked up into an oval cocoon to inclose the pupa. But there is this difference, whereas the cocoon of *Hypera* is a network, that of *Cionus* is a continuous papery layer without openings, so that the chrysalis is entirely hidden. The structure, in fact, reminds one of a child's air ball, and within it the chrysalis lies free, rattling against the sides when shaken. Within its balloon-like covering the insect lies for about a week, when it casts its last skin, cuts nearly off a neat segment from the bottom of the cocoon, and crawls out through the hole. From the above it will be seen that these beetle cocoons are not strictly comparable with those of moths, inasmuch as the material of which they are composed is secreted, not by a gland opening beneath the mouth, but by one which opens upon the upper surface of the last segment of the body.

A third order of insects, the Hymenoptera, now claims our attention, for the habit of cocoon forming is widely extended, and occurs among most of the groups of insects whose metamorphosis is complete. Our illustrations will be taken from the parasitic members of this extensive order, which go by the general name of ichneumon flies. They are long-legged, thin-bodied, four-winged insects, with long antennæ and very often with the body terminating in a longer or shorter stick-like ovipositor. Most of them are during their larvahood internal parasites of other insects, their footless maggots living inside the bodies of caterpillars and other larvæ, and subsisting at the expense of the tissues of their hosts, whose ruin they thus achieve. Of these creatures, two extensive and well defined families are recognized—the *Ichneumonidæ* and the *Braconidæ*. These two groups are very similar in general appearance, and certain members of the one family closely mimic certain of the other, so that a novice who did not know exactly what points to look for in endeavoring to distinguish them would probably consider as identical two insects that would be in reality widely different, as would at once become evident if their whole life histories could be simultaneously passed in review. But they may very easily be distinguished by paying attention to the arrangement of the nervures of the forewings. A comparison of the two wings in Fig. 8 will at once make this plain. In both there is a dark spot, called the "stigma," more than half way along the upper margin of the wing; in the Ichneumonid the space immediately beneath this forms a large cell of a more or less distinctly five-sided outline and with its lower and outer edge

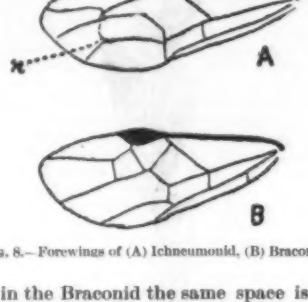


FIG. 8.—Forewings of (A) Ichneumonid, (B) Braconid.

concave; in the Braconid the same space is occupied by three cells, each roughly four-sided. The little nervure marked *n* also is present in the one and absent in the other. There is endless diversity in the actual forms of these cells in the different genera, but the general plan remains much the same, and will usually serve to distinguish a Braconid from an Ichneumonid pretty readily.

Both of these groups of parasites make cocoons, many of which closely resemble those of the Lepidoptera, except that they are, most of them, smaller. But as the larvæ are naked maggots instead of hairy caterpillars, of course the cocoons are always composed purely of silk, and contain no hairs. As might be expected from the shape of the perfect insects, the cocoons are of a long, narrow form, equally rounded at each end; they are of all shades of color, from the purest white to the deepest black. A large reddish-yellow Ichneumonid, *Paniscus testaceus* by name, which is very destructive to the puss moth, makes a thick, rough, dull blackish-brown cocoon. Except by those who rear the hosts, these cocoons are not likely to be seen, as they are to be found only inside the cocoon of the moth; for the parasite does not reach maturity till after its host has immured itself. Another ichneumon, strikingly like the last, and easily mistaken for it, though belonging to a different genus (*Ophion*), makes a totally different cocoon; it is much like those of the egger moths, only narrower—oval, yellowish-brown, and covered with a network of black threads. A species of Braconid (*Zele testaceator*), exceedingly like this again, though much less common, provides for itself a most elegant envelope of a satiny white appearance. Thus we have three species which superficially bear a close resemblance to one another, but which construct totally different cocoons. Some of the smaller kinds make very pretty cocoons; a little Ichneumonid parasitic on the weevil (*Hypera variabilis*), above described, makes a minute reddish-brown one with a neat white band round the middle (Fig. 9), and many others are similarly adorned.

FIG. 9.—Banded and Tailed Cocoons of Ichneumon Flies.

Many of these cocoons may be found among the herbage in woods, hedges, etc., though their small size of course necessitates a careful search; after the disclosure of the flies, they appear to last for some months, and may be found lying about among dead leaves and other rubbish.

Among Braconids, there is a large number of small species which are great scourges to the caterpillars of moths and butterflies; they live gregariously in their hosts, and when full fed they eat their way out, and construct their neat little white, buff, or yellow cocoons in clusters round and over the shriveled remains of their victim. The caterpillar of the common white butterfly (*Pieris rapæ*) may often be seen on walls, treated in this way, its crumpled and distorted carcass being almost hidden under a cluster of little oval silken spindles. One curious genus makes glossy brown cocoons, from one end of which a long, stout, and much twisted anchoring thread proceeds, to the extent of some three or four times the length of the cocoon (Fig. 9); the method of its formation is not easy to understand. Some gregarious Braconids unite their cocoons together, deeply embedding them in a common mass of silk which entirely conceals their outlines, and makes the whole look more like a single cocoon of a moderate sized moth than a cluster of small ones. The possibility of such an association, of course, depends upon their all reaching the pupating stage at the same time; but there is no difficulty about this, for the eggs are all deposited in the host's body on the same occasion, and as the maggots are always completely surrounded by their food, the juices and tissues of their host, they all have equal chances of development, and therefore reach maturity together. The flies also emerge in company.

VARIABLE STARS.

By Prof. C. A. YOUNG.

FOR the most part the stars maintain their places and brightness apparently unchanged: the heavens of to-day are substantially the same as those of Job and Homer. The comparison of a modern star catalogue with that of Hipparchus as preserved by Ptolemy shows that with few and generally slight exceptions the principal stars still hold the same relative positions and the same rank in brightness which they did two thousand years ago. And yet we know that all the time they have been swiftly moving in all directions at rates sometimes exceeding one hundred miles a second—some approaching us and some receding. Then, too, they have all been growing old together, some advancing from stellar infancy toward adult vigor and some descending toward extinction. The apparent permanence is apparent only—due simply to the fact that the scale of human life and all our terrestrial surroundings is practically infinitesimal as compared with that of the stellar universe. Even the nearest star is so remote that if it were rushing directly toward us with the speed of one hundred miles a second it would gain in brightness only about two and a half per cent. in a century, an amount barely observable by our best photometers. As to changes due merely to advancing age, a century bears only some such ratio to the lifetime of a star as a single minute to that of an aged man.

But while all this is true there are several hundred stars which are known as "variables," and undergo considerable changes of brightness, sometimes quite rapidly. They form the subject of a most interesting and important chapter in astronomy—a chapter which may be regarded as opened by Tycho's observations of the marvelous star of 1572, but even yet only begun; in fact, nearly all the systematic work that has been done in this line has been accomplished within the last sixty years.

These "variables" may be roughly classified as follows. First, we have a few stars that seem to be gradually and more or less steadily growing brighter or fainter, judging from their present rank as compared with that which they used to hold; Alpha Geminorum is a case in point, being now distinctly fainter than its neighbor, Beta, although presumably when Bayer assigned the letters, about eight hundred years ago, the reverse was the case. A second class consists of those which oscillate in brightness, but without any apparent regularity, like Eta Argus and Alpha Orionis. The third class is made up of the so-called "temporary stars"—stars which suddenly shine out, and after a few months disappear or become very faint. There have been about a dozen instances of this kind, the last being the "new star in Auriga," which appeared in 1892. The fourth class, and by far the most numerous, is made up of those which vary periodically in brightness in a manner which admits of mathematical prediction. Among these periodic stars at least three sub-classes are to be distinguished: (*a*) those which at regular intervals brighten up for a comparatively short time and then fall back to their normal condition until the next maximum. These are often referred to as the "Omicron Ceti type," because that star usually called Mira, or the "wonderful," is the most conspicuous and longest known of all that belong to it. The majority of the periodic stars belong to this sub-class, and generally repeat their changes about once a year, though their periods range all the way from one hundred and ten days to six hundred and ten. (*b*) The second sub-class includes the stars which, like Beta Lyræ, are in a continual state of activity; they often present more than one maximum of brightness within a single complete period, which is usually somewhere between five days and sixty. (*c*) Finally, we have the ten stars of the so-called "Algol type," which behave in a manner precisely the opposite of that of the stars of the first sub-class: *i. e.*, they undergo periodical diminutions or eclipses of their light, remaining for the remainder of the time steadily bright. Their periods are always short, ranging from seven hours to ten days. The type of the class is Beta Persei, better known as Algol.

The variations of the stars of this class can be very simply explained as merely due to actual eclipses, and the truth of this explanation has been practically established within the last three years by the spectroscopic work of Vogel, at Potsdam. The period of Algol is a trifle under sixty-nine hours, and the photographs show that seventeen hours before the obscuration the lines of its spectrum are displaced toward the red by an amount which indicates that it is then receding from us at the rate of about twenty-seven miles a second, while seventeen hours after the obscuration it is found to be approaching at the same rate; in short, the observations prove that the star is moving in an orbit nearly circular, a little more than two million miles in diameter, and lying in a plane nearly passing through the observer. Now if the periodical obscuration is really caused by the interposition of an eclipsing body, the bright star must necessarily circulate around the common center of gravity between itself and its dusky attendant in just this sort of way, and the detection of such motion falls little short of a demonstration of the hypothesis. We may go further; taking into account the fact that the whole "eclipse" lasts for about eight hours, and that the star loses about two thirds of its light at the time of maximum obscuration (when the brightness remains without change for about twenty minutes), it can be safely inferred that the dark attendant is just about four fifths the diameter of the bright star, and about half as heavy. Also that the distance between the two is about 3,250,000 miles, the diameters of the two bodies being respectively about 1,000,000 and 840,000 miles. Moreover, the combined mass of the two is about two thirds that of the sun, and their density only one fifth as great—not much exceeding that of cork. Nor is this all; since the discovery of the variability of the star in 1782, a slight but distinct variation of the period has been observed, of such a character as to set the times of eclipse alternately backward and forward by about two hours and a half in the interval between 1804 and 1869. From this, combined with certain minute irregularities in the "proper motion" of the star, Mr. Chandler two years ago showed that Algol and its companion must be moving together in a great orbit, nearly as large as that of the planet Uranus, completing the revolution in a period of about one hundred and thirty years; at least, such a revolution would account for the facts, while no other hypothesis yet proposed will do so. And if this revolution is real, it must be around some neighboring body, so faintly luminous that it has not yet been detected. The story of Algol opens to us a new universe of "dark stars"—bodies invisible, but massive and powerful. Presum

ably the other stars of the Algol class admit of a similar explanation, although as yet they have not been spectroscopically studied, being all of them small, and too faint for investigation with the instruments at present available. When the great Yerkes telescope, now nearing completion, is mounted at Lake Geneva it is expected that one of its earliest applications will be to investigations of this sort. It should be added also that certain peculiarities in the light curves of some of these stars seem to indicate that we have not quite reached the bottom of the matter—that in addition to the eclipse, and perhaps caused by it, there are real variations in the light-giving power of the star.

As to the other classes of variables, there is no such satisfactory explanation, nor any generally received theory. In the case of Beta Lyræ and its congeners, we have apparently mechanical and other causes combined—the axial revolution of a star, perhaps, or possibly the whirling of a group of stars, accompanied by tidal changes in the brightness and spectroscopic characteristics of their light: for while the minima of the Algol variables are not accompanied by any alteration of the character of the lines in their spectra, it is not so with the other variables; their spectra are almost all of them characterized by bright lines, which become especially brillant at the time of maximum brightness. Beta Lyræ presents conspicuously in its spectrum both bright and dark lines, due to hydrogen; and these shift back and forth with reference to each other in such a way as apparently to indicate the presence of two or more bodies whirling around each other, one of them giving the ordinary dark line spectrum and the other the bright line spectrum of the gas.

The stars of the first and much the most numerous sub-class are nearly all distinctly red, and show in their spectra the bright lines of hydrogen, but do not as yet furnish any certain evidence that their periodicity is of a mechanical origin—due, that is, to a revolution of some sort. Possibly the explanation proposed by Lockyer may ultimately be verified—that the sudden evolution of light is due to the collision between two swarms of meteors which revolve around their common center of gravity, and brush against each other as they pass their perihelion point. But the periodicity of this class of variables is hardly regular enough to suit this explanation, and the sudden outburst of the bright lines in the spectrum of a star suggests rather some such action, though on a vastly grander scale, as that which causes the sun spots and the solar prominences—causes operating within the star itself.

As to the "temporary stars" opinion is much divided. On the one hand, Lockyer and his numerous followers attribute the phenomena to the collision of swarms of meteors, while on the other, Huggins and Vogel are disposed to assimilate them to the solar eruptions. The latest instance of the kind—the "Nova Aurigæ" already alluded to—which appeared in February, 1892, has been most exhaustively studied by a great number of observers. It is agreed on all hands that at first its spectrum was full of bright lines, and dark lines also; and that among these lines those of hydrogen, both bright and dark, were specially conspicuous, just as in the spectrum of Beta Lyræ; and, moreover, that the bright lines were so shifted toward the red end of the spectrum with respect to the dark lines as to indicate the tremendous relative velocity of more than five hundred miles a second in the two masses to which the lines were respectively due. As to the other lines there was dispute. Lockyer maintained that they were the same that are found in the nebulæ; other observers, no doubt correctly, identified them with certain lines which are conspicuous in the spectrum of the solar chromosphere in every important eruption. The star faded to apparent extinction in April, 1892, but most unexpectedly brightened up again the following August, though not so as to be seen with the naked eye; with the telescope it is still visible. Its spectrum, however, has undergone a remarkable transformation, many of the lines which were formerly most conspicuous having disappeared, while others have taken their place, so that at present it is unquestionably a nebular spectrum. As Mr. Campbell, of the Lick Observatory, who has perhaps the best right to speak authoritatively, puts it, "The lines of the present spectrum do not occupy the positions of the lines in the February spectrum, nor the positions of the lines in the solar chromosphere, nor the positions of the lines in the spectra of any of the bright line stars; they do occupy the positions of the lines in the nebulæ, and the spectrum resembles nebula spectra as closely as well known nebula spectra resemble each other." This is said in answer to some high authorities who find it difficult to admit so surprising a fact as such a transformation. It certainly looks as if we had to do with a reversion of the ordinary course of stellar development; instead of the formation of a star by the slow condensation of a nebula, we seem to have the sudden formation of a nebula by the violent explosion of a star. But speculation on so small a basis of fact is hardly sound.

I must not close without a reference to the important, though unpretending, catalogue of variable stars just published by Mr. Chandler, of Cambridge, who, since the death of Schönfeld, may be regarded as at the head of the department of variable stars, so far at least as relates to the mathematical aspects of the subject. The first step to any real mastery of it must be an accurate collection of facts, such as this catalogue embodies. It gives a list of all the stars which are certainly known at present to be variable, two hundred and sixty in number (sixty-two of them naked eye stars) and adds a subsidiary list of one hundred more which are more or less strongly suspected. Of the two hundred and sixty, about thirty-five are known to be irregular and unpredictable in their variations, and about as many more are still in doubt as regards the periodicity of their changes. The remaining one hundred and ninety are clearly periodic, and Mr. Chandler gives for each of them the formula by means of which its variations can be predicted, thus embodying in a few modest figures the result of an enormous amount of skillful labor. Ten of the variables belong to the Algol class, about twenty-five to that of Beta Lyræ, and the rest resemble Omicron Ceti more or less perfectly. It should be added also that the list of variables is constantly growing—chiefly, of course, amoung the telescopic stars.—*Popular Science News.*

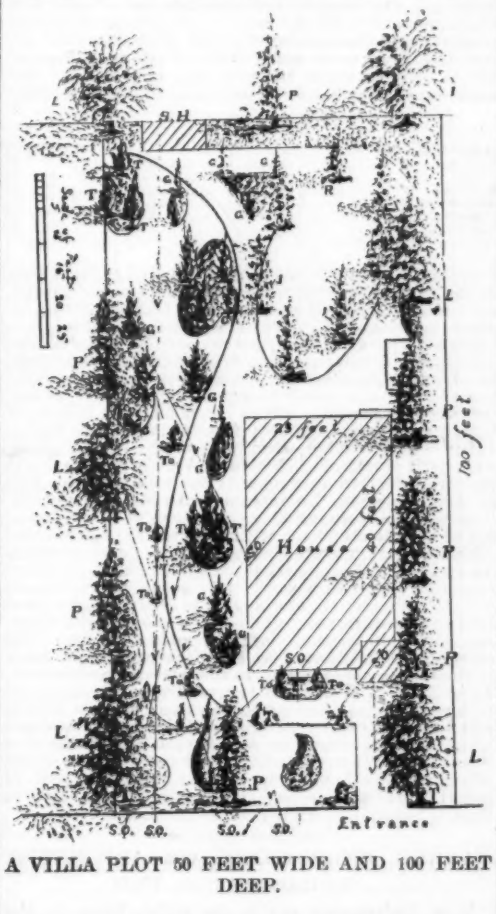
HOME GROUND ARRANGEMENT.

THE plants we recommend are not intended to limit the reader to those named, but to demonstrate that results are attained only by following character. We have selected the Western Arbor Vitæ for the shrub effects, and do not allow anything to interfere with its prerogatives in its views, but in adding more variety to the garden we select suitable forms for the development of its particular character. This genera of plants is suitable to the colder parts of America; the genera of Biota can be used in the Southern States.

The shade trees for our plot are Tilia Europæa, the linden or lime, trees that give dense shade; when in flower they fill the air with delicate perfume, and they should be in more general cultivation.

Pinus larico, the Corsican pine, is well known by its erect habit, which makes it particularly suitable for small places. The oval space behind the house shows three silver Irish junipers (*Juniperus communis hibernica*). Back of this oval is planted Salisburia adiantifolia, the maiden hair tree or Gingko, one of the remarkable trees of Japan, a plant combining quick growth with a curious light effect.

The five beds in front of the house are for summer flowers; the nine oval groups shown on plan are to be planted with suitable herbaceous plants according to the owner's requirements. In addition to the shrubs already named the three figures on the left hand boundary should have a dozen hollyhocks distributed, four in a bed; then generally over all the groups, herbaceous plants, phloxes, double rockets (Hesperia matronalis), Penststemon, not forgetting the sweet smelling common wall flower. The beds will then be ready for their final carpet, so that the whole will be completely planted and cover the intervals of soil between the plants we have named; for this we



A VILLA PLOT 50 FEET WIDE AND 100 FEET DEEP.

recommend Ampelopsis Veitchii (Japan ivy), which carpets the ground as well as walls when the opportunity is given it. The border in the rear of plot may be used for vegetables.

The general arrangement of this plot is gravel around the house and the beds set in the gravel will require permanent edgings. We recommend it made to show a stone work; this may be easily done by a bricklayer, who should lay a brick flat long ways around the figures, letting its top surface be two inches below the general level to act as a foundation for another brick set on its edge all the way around on the top of it. These require to be kept in the curves as perfectly as possible; then the bricklayer will take his concrete, made of cement and sand, and whirl the whole figure into perfect form. The three trees in the gravel on the right hand side of the house must have plenty of good soil provided for their roots, to be covered with a light coating of gravel, not over two inches deep, so as to carry out the plan.

The usually vacant ground along the side of the house can thus be turned into a perfect charm to both the house and road prospects. Wherever a house is made pleasant to the sight its material value is largely increased, and above all this general good is produced, for a pleasing natural effect sways the life of all beholders, knowingly or unknowingly, and he who produces a beautiful prospect is a public benefactor.

Our plan shows a perpetual garden residence on a plot of land 100×50 feet, and by adopting the natural arrangements you may imagine yourself taking fifty different views over it; you will never see two alike, and more than this, you will always find each one in harmony, in repose, in character, and possessing no objectionable features, these being planted away.

Narrow views are weak points; we show none, but instead direct the eye upon every occasion to the length of the ground by the formation of groups as shown on the plan. Harmony is retained by adopting the character of the Arbor Vitæ in mid-distance; repose is acquired by uniting the ground line, mid-distance and sky line together.

ABBREVIATION OF PLAN.

L—Tilia Europæa.
J—Juniperus communis hibernica.
T—Thuja occidentalis Vervæneana.
G—Thuja occidentalis, George Peabody.
To—Thuja occidentalis, Tom Thumb.
P—Pinus larico.
R—Salisburia adiantifolia.
S, H—Summer house.
S, O—Sites of observation.
V—Lines of sight.
H—House.
E—Entrance. —*American Gardening.*

ROSE CULTURE IN BULGARIA.*

THE culture of roses in Bulgaria for the purpose of extracting the otto of rose is not only the oldest and most attractive industry of the country, but also quite exclusively our own. While roses are found all over the world and are grown everywhere in garden beds, in Bulgaria they are grown in extensive fields, as you grow here the potato or the vine. This industry, however, is confined only to one special district in Bulgaria, which is comprised in the eight counties above mentioned, with Kizanlik as their central town, called in consequence the capital of the rose district. The rose district extends along that portion of the southern slopes of the Balkan Mountains, comprising in itself the whole branch range of the Little Balkans, which shoots out of the main Balkans and forms one of its chief arms. The average length of the rose district is about eighty miles, and its average width is about thirty miles. Its average elevation is about 1,300 feet above the level of the sea. The average height of the Balkans along the rose district is about 5,600 feet, while that of the Little Balkans is about 3,700 feet.

Attempts have often been made to grow roses all over Bulgaria, but they have all proved a failure. It is true that roses have been grown and are grown to this day in Persia, India, Egypt and China for this purpose, but they hardly produce any otto of rose. They produce almost exclusively rosewater, and it is chiefly used for local consumption. In the "Maritime Alps" of southern France, and especially in Cannes and Grasse, they grow quite extensively the "Provence rose," and they extract from it a peculiar otto of rose, but the quantity is very limited and they chiefly use their flowers to make pomades and rosewater. In Leipzig, Germany, they also grow the roses, but with very little success. Almost in all the other places where the roses are grown they lack the peculiar advantages of climate we possess, and have in consequence to use twice and even thrice the quantity of flowers to make the same amount of otto. The hottest weather we ever experience in summer is 88° F. and the coldest of winter is rarely under 15° F. above zero. Then, during the harvest and the distillation season, which is in the latter part of May and the first part of June, we have regular showers of rain, and in the mornings heavy falls of dew—both absolutely necessary for the otto of rose distillation.

After the Russo-Turkish war in 1877–78, when Bulgaria was separated from Turkey and constituted into an independent principality, the Turkish government spent thousands of dollars in trying to replant the Kizanlik rose in Asia Minor, and many scores of rose gardens were planted around Broussa, but to no purpose. The gardens grew, thrived and yielded plenty of flowers, but when distilled they got only rosewater, and very little otto, and the work in consequence could not pay. It is the peculiarity of the soil and chiefly that of the atmosphere of this special district in Bulgaria, caused by the peculiar formation of the mountain ranges surrounding it, which make the roses thrive and yield sufficient otto of rose to pay for the very laborious work that the culture entails.

The roses we grow are only of two kinds: red and white. The red rose, which affords the chief ingredient of the otto, is of the variety known as *Rosa Damascena*, and the white rose is a variety of the musk rose (*Rosa Muschatta*). These two varieties are grown nearly everywhere, but nowhere in the world do they resemble our roses.

Our red rose is a semi-double light red rose like the French *rose du roi*, having from thirty to thirty-six petals and possessing an extremely rich and fragrant odor. There are now in the entire rose district over 5,500 acres of rose gardens scattered in 150 different villages, and at the end of May, when the roses begin to blossom, the whole atmosphere in the district is full of their aroma.

The growing of the rose is very much like the growth of the vine, and the planting of a rose garden is similar to that of a vineyard. After the ground has been prepared by tilling and manuring, ditches are made in rows, about a foot and a half in depth and width and a yard and a half apart. At the bottom of these ditches soft earth mixed with manure is spread, on which the roots forming the bushes of the new rose garden and taken from old bushes are firmly stuck vertically, and then well covered with the earth and manure. This is generally done in the spring, when the rain showers abound. The roses thus planted soon take root, and in less than two months send up soft, glossy, green shoots, which in a year become about a foot high. In the second year they are over two feet high, and yield a few rose flowers. The first crop worth gathering is in the third year, and in the fifth year they attain their full growth. They reach then a height of about six feet, the bushes forming thick rows of clustered rose trees and continuing to yield rich crops of flowers for a period of twenty years, and in some localities twenty-five years, after the lapse of which time they become old, begin to die from the winter's cold and frost, and yield but few flowers. Then the old rose bushes are dug out and the garden is planted anew.

A rose garden requires constant care. During the year it is hoed three times. In autumn the roots are covered up with earth to guard them from the win-

* From the World's Fair circular of Shipkoff & Co., Kizanlik.

ter's cold. In spring that earth is thrown off and the bushes are pruned and every other year the garden is manured.

The roses yield only one crop every year. The rose harvest begins in the second part of May, and as the weather is dry and hot or cool and rainy during the blossoming season, it may last from eighteen to thirty days. During the whole harvest the distillation of the crop is carried on. Morning after morning, hours before sunrise groups of young maidens and boys, all dressed in their beautiful bright colored native costumes, proceed with sweet songs to the rose gardens to gather the newly opened buds, while the heavy morning dew is still on the blossoms. Nothing can present a more captivating scene than a rose garden in bloom, with its gayly attired peasant girls gathering the roses, and its nightingales—those romantic lovers of the *Regina florum*—trying in most melodious song to outsing the maidens.

As soon as the roses are gathered they are taken to the distillery, spread in cool and shady rooms and gradually distilled during the day. The alembics used for this purpose are of the simplest kind. They consist of a convex tinned copper boiler, narrowed at the top to a neck on which is fixed a spherical head piece with a tube on one side, to which is attached the condensing tube, sloping down and passing through the condenser or refrigerator, a large vessel into which cold water is constantly running. The capacity of the boiler is about 250 pounds of water. In distilling the roses from twenty to twenty-five pounds of flowers are put in it and from five to six times that much of water, thus filling nearly three-fourths of the boiler. This done the headpiece and condensing tube are tightly attached, the fire started and the distilling of its contents begun. This is carried on about forty-five minutes, until thirty to thirty-five pounds of rosewater are extracted from each boiler. The boilers are then emptied, cleansed with clear water and the same process is repeated until all the morning gathered flowers are distilled. The rosewater extracted from the first distillation is redistilled in the same way, only in this second distillation from 100 to 120 pounds of rosewater is used, and out of it they extract some thirty to thirty-five pounds of second rosewater. This double distilled rosewater is very strong in odor and quite turbid in appearance; it is full of tiny yellow white oily globules floating in it, and as the bottle is filled they rise up and gather on the top of the long-necked bottles in which the rosewater runs. These globules are the otto of rose, and when all the oil has settled on the tops of the bottles it is skimmed and put in separate bottles by little conic-like spoons, with a little hole in the bottom, large enough to let the water run out, but not the oil.

There are at present about 5,500 acres of rose gardens in the entire rose district, which produce annually from 17,000,000 to 21,000,000 pounds of flowers or about 5,400,000,000 roses. A rose garden an acre large yields under the most favorable circumstances from 4,000 to 4,500 pounds of roses, out of which amount is extracted from twenty to twenty-five ounces of otto of rose. It takes generally from 180 to 220 pounds of roses to make one ounce of otto of rose, and there are about 300 roses to the pound. The total amount of otto of rose produced annually in the whole district varies according to the seasons, from 60,000 to 100,000 ounces of otto of rose. Last year the whole crop amounted to about 60,000 ounces, while this year the crop will not exceed the total sum of 30,000 ounces. Nothing can be positively known of the yield of a crop before it has been fully distilled. Many things damage a crop, as hailstorms in autumn, excessive cold in winter, early and deceptive spring, white frost during the budding season, and hot and dry weather during the harvest. The last two cause the greatest damage to a crop.

Nearly all the otto of rose produced in Bulgaria is exported for consumption abroad. Its three largest markets are Paris, London and New York, from where it is distributed all over the world. All the principal perfumers procure now their supply direct from the native manufacturers and exporters.

PARA.

THE State of Para is the most northern of the United States of Brazil and occupies a vast region. Its territory is estimated at 443,896 square miles, comprising one-seventh of the Brazilian territory and one-thirteenth of the surface of South America. Not only is there such a vast area, but the natural resources are believed to be capable of supporting half the population of Europe. Yet the population is more sparse than that of Iceland, being only about 1·11 per square mile.

India rubber represents nearly two-thirds of the total value of production of the State of Para, and contributes to the state and municipal revenues 25 per cent. of their total amount, with neither loss nor impoverishment to the producer. There are many other valuable products of this state, the export of which, largely to the United States, is constantly on the increase, and the foreign trade gives employment to a number of important steamship lines. The Amazon Steam Navigation Co. (limited), operated with London capital, has a fleet of twenty-nine steamers, whose combined trips last year on the Amazon and its tributaries amounted to over 500,000 miles, one of the lines communicating directly with the republic of Peru and others indirectly with Bolivia and Venezuela. Its income has increased from 34,305 milreis in 1853 to more than 4,000,000 milreis last year. The Maranham Coast Co. employ five steamers, and the Lloyd Brazileira employ twelve steamers, all for interior navigation. The Para and Amazon Co. employ eight paddle wheel steamers. The steamers of the Booth line, established twenty-five years ago, navigate regularly between Para and Manaos and New York and the principal European ports. Ten steamers are employed. Besides, the Red Cross line and the United States and Brazil Mail Steamship Co. employ together fourteen steamers for ocean transportation, and the Lloyd Brazileira seven steamers. The book "The State of Para" enumerates five banks established in Para, besides branches of English banks. There are also two local insurance companies, the Grao-Para Water Co., a paper factory, telephone company, a street car line using American cars, the Para Gas Co., a cold storage company for preserving meats by the freezing system, and many other corporations either projected or in operation.

It is predicted that sooner or later Para will become an important industrial country. Already sugar mills, brick-making machinery and steam sawmills are in operation. Para has 101 sugar estates, thirty-six steam sawmills and thirty-five brick yards. There are also soap factories, oil factories and various sorts of shops and foundries in the city of Para. In the State there are forty-one printing offices and thirty-two newspapers. During the past year there were constructed in the city of Para more than 700 dwellings.

Popular prejudice, to quote from "The State of Para," has always been very great against the climate of this region, considered by many to be the focus of malarial fevers. Passages are given from numerous writers to show that the climate is very much more moderate than might be supposed from the nearness of the city of Para to the equator. Herbert H. Smith writes: "At Para, it is true, people complain of the sultry days, but you shall see a dozen more sultry ones during August in New York. 90° Fah. is about the highest temperature of sunny afternoons, and the evenings are delightfully cool."—*India Rubber World.*

LIME AND ALKALIES UPON INVERT SUGAR.

A NUMBER of experiments have been made by Jesser to ascertain the amount and nature of the non-saccharine products resulting from the action of lime and alkalies upon the invert sugar of beet juice, employing solutions which, like those occurring in practice, contain 0·2-0·4 per cent. Caustic lime acts upon glucose at 80° C., and more intensely at 100° C., producing a decomposition, so that the neutral solution after being twice saturated still contains the same amount of lime, but combined with a smaller amount of organic matter in proportion to the amount of action which has gone on. Levulose is as much acted on at 80° C. as glucose at 100° C. Invert sugar behaves like glucose, and the acids formed neutralize 1·5 molecules of lime for every 2 molecules of glucose decomposed. Unless the action of the lime is very slight, organic substances are always produced which neither reduce nor polarize, before or after inversion, and in neutral solution are scarcely precipitated by lead acetate, but strongly by an ammoniacal solution of this reagent. Alkali carbonates produce an almost immediate precipitate with these lime compounds, and the precipitation is considerable at the ordinary temperature within an hour. On boiling, a large part of what remains dissolved is thrown down. Invert sugar is acted upon in much the same manner by caustic potash, but this solution gives a strong precipitate with lead acetate. At the boiling point, and in dilute solution, the reaction proceeds so regularly it may be made quantitative, an excess of alkali being added and titrated back with acid, the change of color with a litmus indicator being thus rendered sharper. An excess of alkali together with lime acts in precisely the same way. As regards the color of the solutions it may be noted: 1. The moderate action of lime produces a brownish red dull liquid, while on more vigorous action it becomes brighter and more fiery; the subsequent addition of an alkali carbonate produces in the former case a slight, in the latter a considerable, darkening. 2. Moderate action of an alkali gives a clear yellow solution; more energetic action renders it dark and yellowish brown. 3. Energetic action of lime and alkali simultaneously renders it very bright and of a fiery color. When the invert sugar in a diffusion liquid which contains 10 per cent. of sugar and 0·1 per cent. of invert sugar is destroyed, the alkalinity, expressed in lime, is reduced by 0·2 per cent—*Chem. Zeit.*

BAUME'S HYDROMETER, OR AREOMETER.

By HENRY WURTZ, Ph.D.

FEW instruments are in use which have to the present time become of more importance to practical men, and, therefore, indirectly to the mass of mankind, than that which is called Baumé's hydrometer. There are two distinct instruments that come under this name. One of these is used for determining the densities of liquids heavier than water, such as acids, saline and alkaline solutions, sirups, glycerines, milk, urine, etc.; the other—which constitutes our special subject of consideration at present—for determining the densities of oils, naphthas, alcohols and spirits, ethers, essential oils and terpenes, fats and waxes (when melted), and generally all substances lighter than water—the weight of a cubic inch of water at a certain given temperature, and at the mean barometric pressure, 30 inches of mercury, being the standard universally adopted, by the English-speaking nations at least.

It is a remarkable fact that it is but about four years since the value of this standard—the weight of the cubic inch of water—has been known with what may be called scientific accuracy. Attempts were made in 1824 to establish it by act of Parliament, following figures that were subsequently ascertained to date nearly a century ago, when chemical balances and weights were far from possessing the delicacy and precision now reached. It was enacted in 1824 that the cubic inch of distilled water at 62° F. and 30 inches of barometer must weigh precisely 252·458 grains. This figure has passed into the literature of science, and most of the chemical and technological text books present it as a finality. Thus, for example, in Fownes' Manual of Chemistry, which has been used more extensively than any other in our American schools, we find: "A cubic inch of water at 62° F. weighs 252·45 grains." (Edition of 1873, page 135.)

It appears, however, that about 1878 suspicions arose that Nature might refuse to be controlled even by an act of Parliament, and that the balance, as we now have it, must be again appealed to, to establish with exactness this cornerstone figure. About 1880 it was announced by the London Board of Trade that their experts had been working out this problem for more than ten years, and had finally decided that the cubic inch of distilled water at 62° F. weighs 252·286 grains, varying, therefore, from the Parliamentary flat by 0·172 grain. In a cubic foot of water this amounts to 297·216 grains, or more than two-thirds of an ounce avoirdupois: and in a United States gallon of 231 cubic inches to 39¾ grains. In an oil barrel of 42 gallons, the error thus corrected is 1,669½ grains, considerably more than three ounces avoirdupois. The United States gallon by the new figure is 58,278·066 grains=8·32544 pounds avoirdupois, or 8 pounds, 5 ounces, 90½ grains. (See the table below.) By the Parliamentary figure our gallon has been hitherto computed at 58,317·798 grains= 8·331114 pounds, or 8 pounds, 5 ounces, 130½ grains.

These remarks appear to the writer—and, it is hoped, will appear to the reader—a sufficient apology for the presentation here of a new table for the conversion of the degrees of the Baume *pèse esprit* hydrometer into actual weighings. Another similar table, for the *pèse acide* instrument, will also be given at an early day.

It is a curious circumstance that the Baume hydrometer scale—at least the one applied to liquids lighter than water—has, in spite of its competition with some 15 or 20 other hydrometers, which have been more or less in use at intervals during a century, held its own, and has made its way into almost universal use throughout the world. To a scientist, there appear two somewhat serious objections to it:

First, its standard is arbitrary, in this respect resembling that of Fahrenheit's thermometer. Its scale, so far as can now be made out, had its starting point in a solution made by Baumé of 15 parts of what he designated as "sea salt" in 85 parts of water. By this solution he marked the 15th degree on his scale. No chemist has since been able to verify this figure with exactness.

Some results of such attempts are here cited:

	DIFFERENCES FROM BAUME'S RESULT.					
Delezennes, at 54½° F.	at 10° B., 1·077;	at 20°, 1·167;	at 40°, 1·4:	at 60°, 1·75;	at 70°, 2·0
Francœur, "	" " 1·07;	" 1·159;	" 1·357;	" 1·75;	" 1·84
Gilpin, "	" " 1·075:	" 1·161:	" 1·384;	" 1·714;	" 1·98
Morozeau, "	" " 1·075;	" 1·161;	" 1·384;	" 1·711:	" 1·98
Bohnenberger, at 57½° F	" " 1·069;	" 1·148;	" 1·347;	" —	" —
Poggiale,	" " 1·075;	" 1·161;	" 1·383;	" 1·711;	" 1·98
Graham	" " 1·073;	" 1·157;	" 1·375;	" 1·60;	" 1·90

Berthelot and others have found similar discrepancies. These figures prove not only that Baumé's original determination is of little or no value, but further, that his method is apparently not susceptible of giving a precise and invariable standard. This fact has been much speculated on, and it is generally concluded to be due to impurity in Baumé's salt. The present writer does not accept this view, there being another explanation, namely, that it is undeniable, and has been insisted on by himself for many years, that specific gravities are not fixed, inherent and immutable qualities of saline bodies, or of any bodies whatever. They vary, within certain limits, and according to certain laws. These laws the writer has been studying for twenty years. It follows that *solutions* of salts may and do vary also in density. Hence Baumé's standard cannot be realized at all with certainty and precision.

For these reasons, there has been much dispute about the correct formulation of the Baumé degrees, and their conversion into specific gravity figures and the converse. The formula which has been settled upon and is employed is given below.

The second reason why the Baumé *pèse esprit* instrument is not in accordance with scientific habitudes is that the order of the scale is the reverse of the order of densities—that is, the smaller degrees correspond to the heavier liquids. This does not apply to the *pèse acide* instrument. This, which confuses the minds of beginners, easily becomes familiar to the practiced expert. Nevertheless, it causes embarrassment to those not expert in this field, who are often led into mistakes by forgetfulness of this peculiarity of the system.

In spite of the scientific objections that have been briefly discussed, there must be some feature about the Baumé instruments highly acceptable and attractive to practical men, to account for its wide use. Both instruments are universally employed in this country; but in England, for liquids heavier than water, another areometer, that of Twaddell, is used instead, the reasons given being that the degrees are smaller, and the rule converting them into actual specific gravities simpler and easier of application. The *pèse esprit* is, however, in universal use in England also, and both of them largely throughout Europe.

The following table, besides being founded on the new and more accurate determination of the weight of the cubic inch of water, already explained, is fuller and carried out to more places of decimals in column 3 than any hitherto published, so far as the writer knows. Column 4 is probably altogether novel, and, it is hoped, may prove useful, in certain cases, to practical men.

The formulas used in conversion of the degrees of the *pèse esprit* scale to densities and *vice versa* are those of Dr. Pile as adopted in the United States Dispensatory of Wood & Bache.

$$\text{Density} = \frac{140}{\text{Deg. B.} + 130} \quad \text{and}$$

$$\text{Deg. B} = \frac{140}{\text{Density}} - 130$$

Although several other expressions have been proposed and used, yet throughout the literature of the subject the above are most frequently recommended.

Instead of formulas, the modes of getting the figures in columns 3 and 4 of the table will here be stated as simple arithmetical rules.

1. *Column* 3. The figure representing the density in column 2 is multiplied into 8·32544, the true weight in pounds of a gallon of water.

2. *Column* 4. Throw off the first figure in column 3, and multiply the decimal fraction left by 7,000. If the

product obtained is larger than 437·5, divide it by this. The whole number in this second product will be ounces, and the decimal fraction will be grains and decimals thereof. If the first product is smaller than 437·5, the ounces are = 0, and the first product represents the grains and decimals thereof.

3. To reduce from 62° F. to any other standard of temperature. If such temperature is below 62°, add 4·83 grains to column 4 for each degree; if above 62°, deduct 4·83 grains for each degree.

TABLE OF DENSITIES AND WEIGHTS (AT 62° F. AND 30 INCHES BAROMETER) PER UNITED STATES GALLON OF 231 CUBIC INCHES; CORRESPONDING TO THE DEGREES OF BAUMÉ'S HYDROMETER FOR LIGHT LIQUIDS. BY HENRY WURTZ, PH.D.

1.	2.	3.	4.		
			In one gallon of 231 cubic inches.		
Degrees B.	Specific Gravities or Densities.	Avoirdupois Lb. per Gallon.	Lb.	Oz.	Grains.
10	1·0000 (Water)	8·33544	8·	5·	90½
11	0·9929	8·29338	8·	4·	114
12	0·9859	8·20805	8·	3·	144
13	0·9790	8·15061	8·	2·	179
14	0·9722	8·09400	8·	1·	220
15	0·9655	8·03821	8·	0·	267½
16	0·9589	7·98326	7·	15·	320
17	0·9524	7·93445	7·	14·	379
18	0·9460	7·87587	7·	14·	6
19	0·9396	7·82258	7·	13·	70½
20	0·9333	7·77013	7·	12·	141
21	0·9271	7·71868	7·	11·	220
22	0·9210	7·66773	7·	10·	299
23	0·9150	7·61778	7·	9·	387
24	0·9091	7·56866	7·	9·	43
25	0·9032	7·51954	7·	8·	137
26	0·8974	7·47125	7·	7·	226
27	0·8917	7·42379	7·	6·	341½
28	0·8861	7·37717	7·	6·	15
29	0·8805	7·33055	7·	5·	196½
30	0·8750	7·28476	7·	4·	243½
31	0·8695	7·23897	7·	3·	360½
32	0·8641	7·19401	7·	2·	451½
33	0·8588	7·14989	7·	2·	174
34	0·8536	7·10660	7·	1·	308½
35	0·8484	7·06330	7·	1·	5½
36	0·8433	7·02084	7·	0·	146
37	0·8383	6·97922	6·	15·	292
38	0·8333	6·93759	6·	15·	04½
39	0·8284	6·89679	6·	14·	152½
40	0·8235	6·85600	6·	13·	304½
41	0·8187	6·81004	6·	13·	25
42	0·8139	6·77008	6·	12·	182½
43	0·8092	6·73095	6·	11·	346
44	0·8045	6·69182	6·	11·	72
45	0·7999	6·65352	6·	10·	241½
46	0·7954	6·62305	6·	9·	417
47	0·7909	6·58459	6·	9·	154½
48	0·7865	6·54796	6·	8·	335½
49	0·7821	6·51133	6·	8·	70½
50	0·7777	6·47469	6·	7·	260½
51	0·7734	6·43890	6·	7·	10
52	0·7692	6·40393	6·	6·	200½
53	0·7650	6·36896	6·	5·	395
54	0·7608	6·33399	6·	5·	150½
55	0·7567	6·29986	6·	4·	349
56	0·7526	6·26573	6·	4·	110
57	0·7486	6·23242	6·	3·	314½
58	0·7446	6·19912	6·	3·	81½
59	0·7407	6·16665	6·	2·	293½
60	0·7368	6·13418	6·	2·	64½
61	0·7329	6·10171	6·	1·	274½
62	0·7291	6·06925	6·	1·	47
63	0·7253	6·03684	6·	0·	269
64	0·7216	6·00764	6·	0·	53½
65	0·7179	5·97088	5·	15·	275½
66	0·7142	5·94008	5·	15·	57½
67	0·7106	5·91606	5·	14·	287½
68	0·7070	5·88609	5·	14·	77½
69	0·7035	5·85695	5·	13·	311
70	0·7000	5·82781	5·	13·	107
71	0·6965	5·79867	5·	12·	340½
72	0·6930	5·76953	5·	12·	136½
73	0·6896	5·74122	5·	11·	376
74	0·6863	5·71375	5·	11·	183½
75	0·6829	5·68544	5·	10·	423
76	0·6796	5·65797	5·	10·	231
77	0·6763	5·63050	5·	10·	39½
78	0·6731	5·60385	5·	9·	289½
79	0·6699	5·57721	5·	9·	103
80	0·6667	5·55057	5·	8·	354
81	0·6635	5·52393	5·	8·	167½
82	0·6604	5·49812	5·	7·	424½
83	0·6573	5·47231	5·	7·	238½
84	0·6542	5·44650	5·	7·	53
85	0·6512	5·42153	5·	6·	305½
86	0·6482	5·39655	5·	6·	151
87	0·6452	5·37157	5·	5·	413½
88	0·6422	5·34560	5·	5·	231½
89	0·6393	5·32245	5·	5·	09½
90	0·6364	5·29931	5·	4·	328
91	0·6335	5·27417	5·	4·	167
92	0·6306	5·25002	5·	4·	0
93	0·6278	5·22671	5·	3·	274½
94	0·6250	5·20339	5·	3·	111
95	0·6222	5·18009	5·	2·	385½
96	0·6194	5·15850	5·	2·	234½
97	0·6167	5·13430	5·	2·	65
98	0·6140	5·11182	5·	1·	345
99	0·6114	5·09017	5·	1·	193½
100	0·6087	5·06770	5·	1·	
101	0·6061	5·04605	5·	0·	322½
102	0·6035	5·02440	5·	0·	171
103	0·6009	5·00276	5·	0·	19½
104	0·5983	4·98111	4·	15·	305½

[The last two lines in the Table represent the paraffine homologue Butane, the lightest liquid body as yet discovered.]

[Continued from SUPPLEMENT, No. 941, page 15046.]

ALLOYS.*

By Prof. W. CHANDLER ROBERTS-AUSTEN, C.B., F.R.S.

Lectures I. and II.

A NEW phase in the history of the measurement of high temperatures began with the work of Sir William Siemens, who showed that the variations in the electrical resistance of a heated metallic conductor would afford a pyrometric method. The names of Muller, Quincke, and Ressig may be mentioned in connection with early work in this direction, but Siemens was the first to demonstrate the practical nature of the method. The first notice I can find of his experiments is given in a letter to Dr. Tyndall, dated December, 1860. Twelve years later, in a lecture delivered before the members of the Royal Institution,† Siemens makes some interesting remarks on the industrial aspect of pyrometry as limited by capabilities of the mercurial thermometer. He said: "When we ascend the scale of intensity, we soon approach a point at which mercury boils, and from that point upward we are left without a reliable guide; and the result is, that we find in chemical books on chemical processes, statements to the effect that such and such a reaction takes place at a 'dull red,' such another at a 'bright red,' or a 'cherry red,' or a 'white heat,' expressions which remind one," he adds, "of the days of alchemy, rather than chemical science at the present day." With reference to this it may be observed that if, as Sir William says, technical men "were left without a reliable guide" directly the limits of the mercurial thermometer were passed, it was their own fault. The thermo-couples proposed by Becquerel and others would have given them trustworthy measurements of high temperature, but they either lacked knowledge of the sources of information or the skill to use the far from complicated appliances at command. An excellent dead-beat galvanometer, so essential in connection with all pyrometric methods of which electricity is the base, was long ago provided by Sturgeon, but metallurgists, who sadly needed a good pyrometer, were either ignorant of the existence of such physical instruments or untrained in their use, and are now only beginning to recognize the necessity for their adoption.

The nature of Siemens' instrument may be made clear by the accompanying diagram (Fig. 4). A divided current passes from the battery, B, to a platinum wire, C, coiled around a clay cylinder, and to a resistance coil, R. At the ordinary temperature, the resistance of the platinum coil is balanced by the standard resistance, R. If, however, the platinum coil be heated, the resistance, will be increased, and this increase of resistance, which can be measured in various ways, indicates the temperature of the coil, C. The coil itself may be adequately protected and exposed to temperatures, which have been determined by the air thermometer; the deflection of a suitable (differential) galvanometer, G, will then indicate temperatures directly. For instance, the temperature at which zinc boils has been accurately fixed at 940° C., and if the coil is heated in the vapor of boiling zinc, the angle through which the galvanometer mirror is deflected marks the temperature of 940° C.

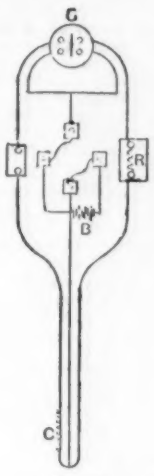


FIG. 4.

For many years this electrical resistance pyrometer was the only appliance believed to be trustworthy, which could be placed in the hands of artificers. Its usefulness was widely recognized, and a committee of the British Association was appointed to report upon it. The result of the inquiry* rather tended to shake confidence in the instrument, as it was shown that it was liable to changes of zero. Mr. H. L. Callendar has, however, done admirable service by proving that, with certain precautions, the method may be rendered trustworthy. He winds the platinum wire on a plate of mica, excludes reducing gases, as the committee suggested, by inclosing the coil in a tube of doubly glazed porcelain, and uses a zero method of measuring the current with the galvanometer.

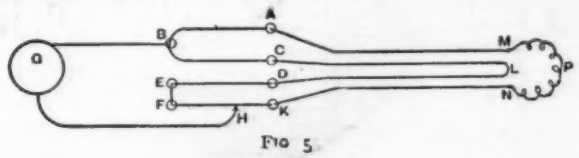


FIG 5.

It will have been evident from what has been already adduced with reference to the works of the Becquerels and of Deville that by the year 1880 two main systems of pyrometry had been well established. These depended respectively on the use of the air thermometer and of thermo-couples. Siemens' electrical pyrometer, though its utility was admitted, was expensive, and confidence in it was not established. The basis of optical pyrometry had been firmly laid, but the measurement of high temperatures by optical methods had not passed into the domain of industrial work.

The publication of the article "Pyrometry," in the last edition of the "Encyclopedia Britannica," in 1886, enables us to judge what progress had been attained at the period when this important work appeared. In 1886, the author of that article, Mr. N. Shaw, who is so eminently qualified to form an opinion, took a distinctly gloomy view of pyrometry. He concludes his excellent article by suggesting doubt whether any of the instruments he describes "can be easily made to take up the temperature of the body or inclosure under investigation," and he says that "perhaps the most important modern attempts at the development of pyrometry are those connected with the identification of the law connecting the temperature with the amount and nature of energy which it radiates, for on such attempts depends the possibility of measuring the temperature of a hot body by means of the light it emits" . . . and he adds that "at present there is no general agreement between scientific men as to the form the relation takes." In 1886, the year Shaw wrote, the beginnings of very distinct advances in practical pyrometry were made. Callendar published the first part of the work that is subsequently developed in his well known paper,* which restored confidence in the electrical resistance pyrometer. In the following year Professor H. Le Chatelier† communicated a paper to the Chemical Society of Paris on the platinum, platinum-rhodium thermo-couple, which gave an entirely new and vigorous impulse to thermo-electric methods of pyrometry, as the form of thermo-couple he employed takes up the temperature of the locality in which it is placed with astonishing rapidity; and Barus established the thoroughly trustworthy character of the platinum, platinum-*iridium* couple, and devised a very ingenious pyrometric method depending on the viscosity of gases.

Fig. 5 represents, somewhat diagrammatically, the arrangement of Callendar's apparatus.‡ A B, B C, are equal resistances, forming the arms of the balance. The battery is connected at A and C, and one terminal of the galvanometer, G and B; D E represents a set of resistance coils, which, together with the resistances, A B and B C, may be supplied by an ordinary box of coils of the "post office" pattern. F K represents a straight bridge wire, with a divided scale attached. The other terminal of the galvanometer is connected to contact piece, H, which slides along this wire. The leads, A M, K N, from the pyrometer coil, P, are connected to A and K; and the compensating leads, C L, L D, the resistance of which is equal to A M, K N, are connected to C and D. These four leads may be of any convenient length; they are symmetrically arranged, so that corresponding parts are always at the same temperature. When the balance is found by inserting suitable resistances in the arm, D E, and sliding the contact piece, H, it is plain that, since the resistances, A B, B C, are equal, the resistance of the pyrometer and its leads, together with that of the length, H K, of the bridge wire, will be equal to the remaining portion, F H, of the bridge wire, together with the coils, D E, and the compensating wires, C L D. Thus, the changes of the resistance of the pyrometer leads, A M, K N, are compensated by the equal changes in the leads, C L, L D, and the resistance of the pyrometer coil itself is directly given by the sum of the coils, D E, and the reading of the bridge wire. The resistance of a centimeter of the bridge wire, F K, is made to correspond to such an increase of the resistance of the pyrometer coil, P, as is produced by a rise of 1° C. The contact key, H, slides along this wire, and the galvanometer can easily be made sensitive to one-hundredth of a centimeter of this bridge wire; so that one-tenth of a centimeter, which corresponds to one-tenth of a degree, can, of course, be measured with certainty. The author has worked for several days at the Royal Mint with Mr. Callendar, and is satisfied that, at temperatures exceeding that of bright redness, the comparative readings are accurate to one-tenth of a degree. This would have been considered impossible a few years ago, and the statement will, perhaps, be received with some incredulity. Later on, evidence will be examined which leads to the belief that, in the measurement of a "white heat," degrees of value similar to those of the ordinary mercurial thermometer are still employed.

The reader will, however, remember that measuring the increased resistance of a heated conductor is not the only way in which electricity has been made serviceable in the measurement of high temperatures. It has long been known that if the junction of two metals be heated, the electrical equilibrium of the system is disturbed, and the measurement of the difference of potential produced affords a means of estimating the temperature of the junction. The use of such thermo-junctions appears, as has already been stated, to have been suggested by A. C. Becquerel in 1826, and adopted by Pouillet ten years later. Unfortunately, the metals composing the thermo-junctions were badly chosen, and their use was consequently greatly retarded until, as already stated, within the last few years, Professor H. Le Chatelier, of Paris, advocated the use of platinum, in conjunction with platinum alloyed with ten per cent. of rhodium. The author first adopted this couple in 1889, and has since constantly used it, in conjunction with a photographic recorder, devised for the purposes of an investigation which was entrusted to him by the Institution of Mechanical Engineers. This instrument will be described presently. In its latest form, the couple consists of two wires, one of platinum and the other of platinum-rhodium alloy, mentioned above, simply twisted at their ends or soldered with gold, and connected with a dead-beat galvanometer of about 200 ohms resistance. The Deprez and D'Arsonval form of galvanometer, particularly the latest type of this instrument, is admirably adapted for use with the thermo-couple.

A photographic method was employed as early as 1887 by H. Le Chatelier§ in connection with his thermo-couple. It consisted in allowing the image of induction sparks, produced at regular intervals of time, to fall on a narrow fixed sensitized strip of glass. If the temperature to which the thermo-couple is exposed is rising or falling at a uniform rate, the photographic images of the sparks will be equidistant, but if there is at any moment an arrest in the rise, or fall, of the temperature, the images of the sparks will then be

* Lectures delivered before the Society of Arts, London, 1893. From the Journal of the Society.

† "Pro. Roy. Inst.," vol. vi., p. 433.

* "British Association Report," 1874, p. 242.

† "Phil. Trans. Royal Soc.," vol. clxxviii., 1887, p. 161, and subsequent papers in the "Phil. Mag." and "Proc. Roy. Soc."

* "Phil. Trans. Roy. Soc.," loc. cit.

† "Bull. Soc. Chim." Paris, vol. xlvii., 1887, p. 2; "Journal de Physique," vol. vi., 1887, p. 23.

‡ "Phil. Magazine," vol. xxxii., 1891, p. 104, and vol. xxxiii., 1892, p. 220.

§ "Compes Rendus," vol. cxiv., 1887, p. 1443.

closer together. The distance between the individual lines affords a method for measuring the rate at which a thermo-couple receives or loses heat from any hot locality or substance in which it may be placed.

The new departure in pyrometry, by which curves are automatically obtained, will now be described. It will be obvious that by confining the image of the mirror to a minute spot, and by moving the sensitized plate at a uniform rate, a time-temperature curve may be traced by the aid of photography. Such curves are often very beautiful, and I have elsewhere shown* that they may yield results of much importance.

The arrangement, which is shown in Fig. 6, consists

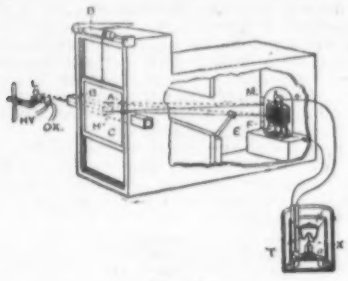


FIG. 6.

of a galvanometer of the Deprez and D'Arsonval type inclosed in a large camera; a fixed mirror, F, is placed below the movable mirror, M, of the galvanometer, so that the light from the line cylinder, L, reflected in the mirror, H, passes to both mirrors, F and M, and is reflected in the direction of a fine horizontal slit, A B; behind which a sensitized photographic plate, C, is drawn vertically past the slit, by means of gearing, D, driven by clockwork. The ray from the fixed mirror is interrupted periodically by the vane, E, and a beaded datum line is given, which enables any irregularity in the advance of the plate to be detected.

The amount of divergence, from its datum line, of the spot of light reflected by the movable mirror at any given moment bears a relation (which can readily be found by calibration) to the temperature to which the thermo-junction, X, is heated; and the variations of temperature will be indicated by a curve, which is the resultant of the upward movement of the plate and the horizontal movement of the spot of light. A crucible, *c*, which may be filled with molten metal, is provided with a tubulure, T, for the insertion of the thermo-junction. The crucible is suspended by wires in a double jacket of tin plate, *a*, *b*.

The author is satisfied that this thermo-junction can afford trustworthy results, accurate to 1°, at temperatures of over 1,000° Centigrade. One important feature of the appliance is the minuteness of the space occupied by the thermo-junction, which may be suitably protected, and inserted into the midst of a very small mass of metal. The pyrometer is calibrated by exposing the thermo-junction to certain known temperatures, such as the solidifying points of salts or metals. There is no difficulty in recognizing the melting or solidifying points; for, as the mass passes from the solid to the fluid state, the temperature remains constant for a brief period, the duration of which depends on the amount of material operated upon, and its latent heat of fusion; the result being that the spot of light from the galvanometer will be arrested, and the position on the scale at which it stops marks the temperature to be determined. A detailed drawing of a more elaborate form of this appliance is given in Fig. 7.

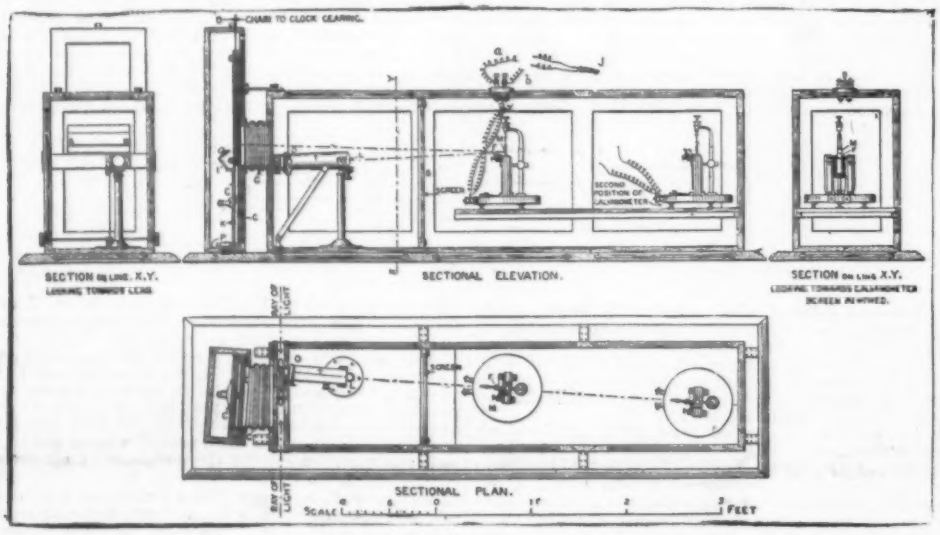


FIG. 7.

The appliance consists, as is shown in the accompanying plate, of a camera about five feet long, in which a galvanometer may be placed in either of two positions, according to the range of temperature to be observed. This camera has three doors, and is made separate from the portion of the apparatus which contains the moving photographic plate, C. The two parts are connected by a flexible leather "bellows" junction, G, the object being to enable the plane of the sensitized plate to be adjusted at right angles to the rays of light from the galvanometer mirrors, F and M. Inside the camera is a focusing tube, T, containing a lens, L, which receives the light from the mirror, H, and transmits it to the mirrors, F and M. One of these mirrors, M, is movable, and is carried by the coil of the galvanometer; while the other, F, is carried upon an adjustable arm fixed to the supports of the galvanometer, its function being to send a ray of light from the mirror, H, to the slit, A B, and thus to trace a datum line as the photographic plate travels upward. The temperature is recorded by the variations in the position of the spot of light received from the mirror, M. There is a screen, S, to cut off light reflected from the brass work of the galvanometer. The end of the tube, T, is provided with an adjustable brass slit, O, by means of which the width of the photographic traces on the plate may be varied. The mirror, H, is mounted on a block, which can be adjusted so that external light may be received from either side.

The focusing of the lens, L, may be effected from outside the camera. Plug connections are provided for at the top of the instrument, and the wires, *a*, *b*, connect the galvanometer with a thermo-couple, J, placed in the furnace or other source of heat. The photographic plate is secured to its carrying slide, C', by means of little cams; and this carrier is inclosed in a case, K, provided with a light-tight door, I. The case, K, is held in position by a pin, P. The connection of the photographic plate with the driving clock is shown at D. It may be mentioned that the galvanometer stands on three plates, which provide the well known combination of the hole, slot, and plane, to insure steadiness. If the sensitized plate be replaced by a revolving drum bearing photographic paper, it will be obvious that a time temperature curve of considerable length can be readily obtained; and such curves afford convenient records of the variations in the temperature of any furnace, or other source of heat, in which the thermo-couple, J, may have been placed.

(To be continued.)

* "Proceedings Roy. Soc.," vol. xlix., 1891, p. 347; vol. l., 1892, p. 367. "Proceedings Institute of Mechanical Engineers," 1891, p. 543, and 1893, p. 102.

NOTE ON AN ABNORMAL MELTING POINT.

By E. J. BEVAN, F.I.C.

IN the course of an examination of a crystalline fatty body obtained from pure lard by fractional crystallization from ether, I had occasion to determine its melting point. For this purpose capillary tubes were filled with the melted body in the usual way. The melting point, determined within a few minutes of filling the tube, was 47° C. Another tube, filled at the same time, but examined the next day, gave a melting point of 61·5°. This tube, after allowing the body to solidify, was plunged into water at 50°, and, to my great surprise, was found to melt instantly to a perfectly clear fluid. The experiment was repeated at intervals down to a temperature of 45·5°, at which point it remained solid. A number of experiments were made on a larger scale, using test tubes internally coated. After standing twenty-four hours, the substance remained solid, when the tube was plunged into water at 50°. One-half of the contents of the tube was then melted over a burner and allowed to solidify.

On plunging the tube into water at 50° it was found that the portion recently heated melted to a clear liquid, the remainder being quite solid and opaque; and the portion melted corresponded exactly with the part of the tube heated.

It is clear, therefore, that the body has two very definite and widely different melting points, and that it passes slowly and spontaneously from the state of low melting point to that of the higher, and can be made to pass from the high to the lower state immediately by simple heating.

As I hope to show you, it can also be made to pass from the lower to the higher state by gradually increasing the temperature.

Thus, I take a tube recently heated and place it in water at about 48°. At this temperature it remains solid; on gradually raising the temperature, I find that the substance melts to a clear liquid at about 47°. If now the temperature be still further gradually increased, the substance passes again into the solid state at about 53°, and does not melt again till a temperature of about 62° is reached.

The existence of the two melting points was confirmed by the use of Cross and Bevan's method, as described in the *Chem. Soc. Jour.* for 1882.

These experiments emphasize the importance, which has before been insisted on, of delaying the determination of melting points for some hours after the substance has been melted.

It has since been pointed out to me by Mr. Allen that some curious experiments by Mr. T. Maltby Clague on the alteration of the melting point of cocoa butter are recorded on page 570 of his *Commercial Organic Analysis*, vol. iii., part ii.

The chairman (Mr. Otto Hehner) remarked that the subject was very important. Analysts often met with such difficulties in analyzing fatty substances. It would be very desirable to come to some agreement as to the conditions under which the melting point of a fat ought to be taken.—*The Analyst*, December, 1893.

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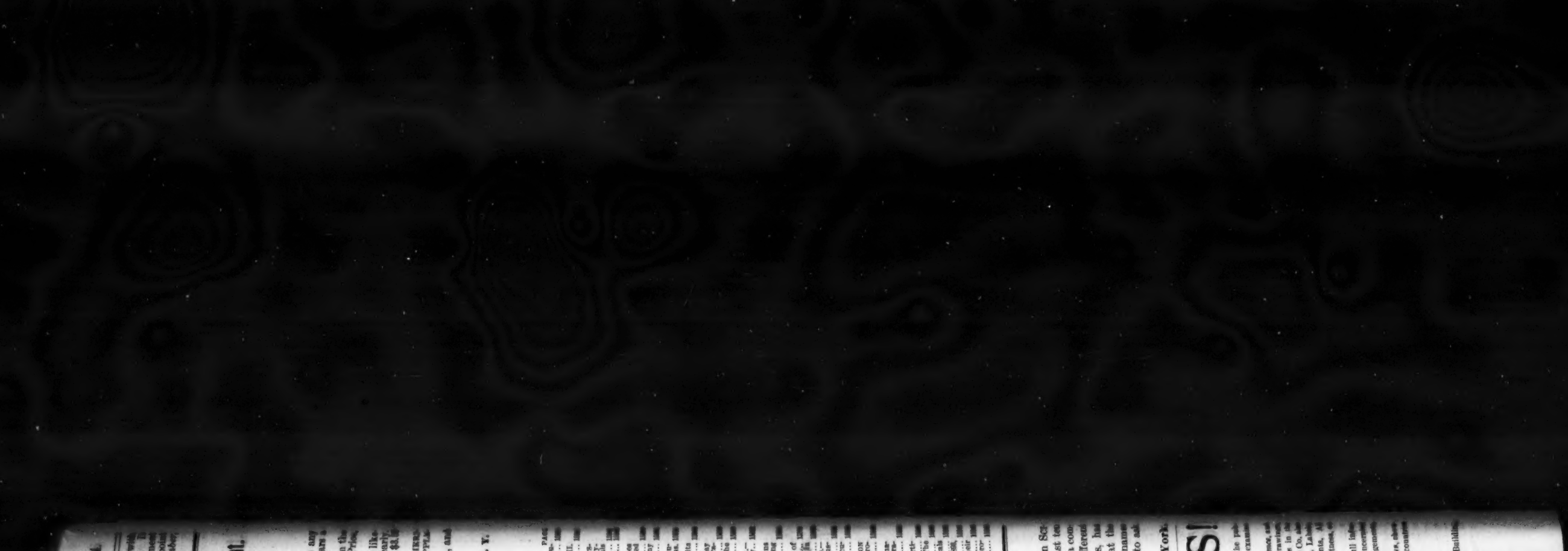
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